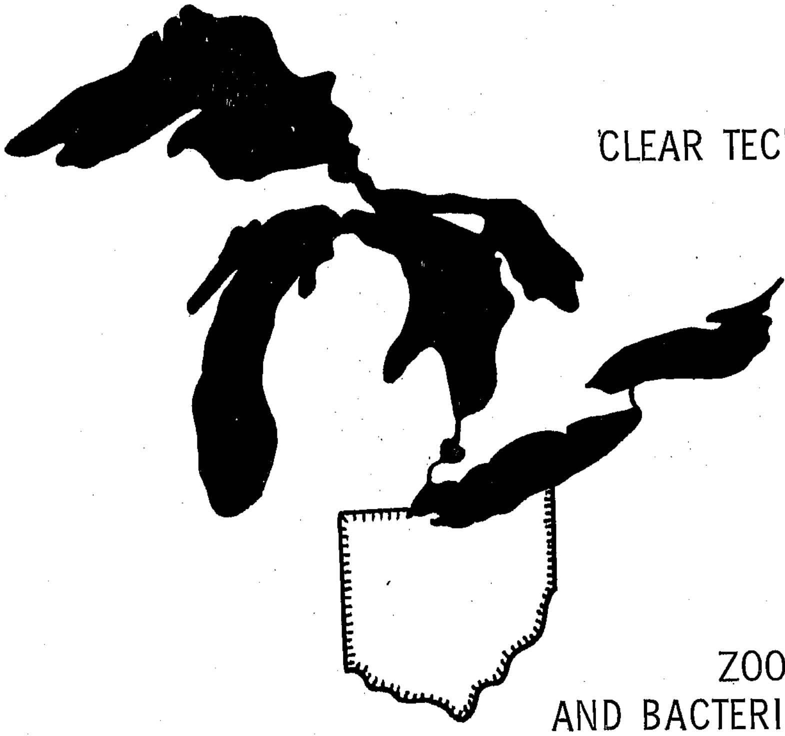

CLEAR TECHNICAL REPORT NO. 86

ZOOPLANKTON, PHYTOPLANKTON, AND BACTERIA AS INDICATORS OF WATER QUALITY IN THE NEARSHORE ZONE OF LAKE ERIE: A PROSPECTUS

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ZOOPLANKTON PRELIMINARY FIELD STUDY 1977

METHODS:

Zooplankton samples were collected from five stations in the nearshore zone of the Western Basin of Lake Erie in July 1977, using a 30 l Schindler-Patalas plankton trap equipped with 63 μ netting. The entire water column was sampled by sequentially sampling 0.5 m strata (the trap is 0.5 m tall by .25 m x 25 m) from the top to the bottom. Station locations (Fig. 1) were selected to be typical of the nearshore zone in the Western Basin. Samples were preserved with 4% formaldehyde in the field.

In the laboratory, the zooplankton were quantitatively subsampled after being diluted to a concentration where a 5 cc subsample contained a minimum of 200 of the most abundant species and stage (e.g. *Diaptomus siciloides* adult male). Two replicate counts were made from the diluted sample and the average result reported as organisms per liter (Table 1). Identifications were made according to Ward and Whipple (1959) for Crustacea and Chengalath et al., (1971) for Rotifera. During 1978, the samples will be analyzed further to give size frequency information which will enable us to calculate biomass estimates from regressions appearing in Boucherle et al., (1978) and to calculate secondary productivity using a computer program constructed by Culver (1978). Calculation of productivity will allow us to estimate rates of biomass addition in the zooplankton community based entirely on standing crop samples collected as these were done.

RESULTS:

From even these single date samples it is evident that there is tremendous variation in the abundance of zooplankton as well as the diversity of species found. Note that stations 76 and L24 are very near one another, and the abundances of *Cyclops vernalis* females are similar (2.08 and 1.33 l^{-1} respectively) yet the abundance of eggs is 14.74 at station 76 and zero at L24. Accordingly, the production of the adults (output of eggs) is much greater at 76 than at L24 although abundances are similar.

Introduction

Recent studies of the offshore waters of Lake Erie have demonstrated the utility of studies of the zoo-, phyto- and bacterioplankton as indicators of water quality in the lake. Collectively, they constitute the most important components of the pelagic community and thus can tell us a great deal about the character and condition of the lake. Due to the difficulty of sampling in rough weather in shallow waters, the Lake Erie nearshore has not been adequately examined for water quality by the same parameters. It is the purpose of this prospectus to report on progress on a literature survey of what information is currently available on the nearshore plankton of Lake Erie.

Not only has the nearshore been inadequately sampled to say much about plankton as indicators of water quality, but the overall ability of investigators to characterize water quality from plankton samples is as yet poorly developed.

The literature survey indicates that not only has the nearshore plankton been poorly sampled, but also that straight taxonomic enumeration surveys will do little to characterize the water quality of the nearshore zone. Some new data on zooplankton abundance in the nearshore zone of the Western Basin of Lake Erie are included in this prospectus as well as suggestions on how these and other planktonic organisms should be used to increase our information about water quality in the nearshore. Specifically, it is suggested that measurements of primary productivity, secondary productivity, and population dynamics be performed on a regular basis to measure the growth rates of the planktonic community rather than simply assessing relative abundance on a regular basis.

Zooplankton

Zooplankton abundance and species composition cannot as yet tell us a great deal about the quality of waters in Lake Erie. A few generalizations such as the switch from diaptomid to cyclopoid copepods with increasing eutrophication have been proposed, but no convincing mechanism for this switch has been produced. Toxicological work with Great Lakes zooplankton has for the most part been limited to *Daphnia pulex* and is not particularly useful since it has typically been performed on single substances in the laboratory, while the cladocerans in nature must survive the onslaught of all such chemicals simultaneously. Attempting to assess water quality by comparing the survival of this and other species in the field as compared to LC_{50}s from the lab will accordingly not tell us much.

At 20°C, *Daphnia galeata mendotae* eggs develop in 2.6 days (Hall, 1964) and juveniles probably produce their own first brood at approximately the same interval later. Summer populations thus can pass through 5 generations between monthly surveys of abundance. Examining seasonal patterns of abundance sampling every 5 generations makes no sense analytically, but represents a tremendous outlay of manpower in collection and analysis of the samples. Monthly samples can be useful if they are analyzed with respect to the rates of processes going on at that time. Data represented in Table 1 indicates the variation in the number of eggs/1 for the different species of crustacean zooplankton at several Lake Erie nearshore stations. Note the differences in abundance of ovigerous females and eggs/ of *Chydorus sphaericus* among the stations. Combined with information on egg development times as a function of temperature, it is possible to compute the rate of growth of these populations at the various stations. Abundance can tell us little about what is going on in the population, but growth rates of the populations may be compared among stations to assess where reproductive output is maximal.

In an analogous way, production of biomass/unit time/m^3 may be calculated from abundance of individual species and eggs, development times, size frequencies, and weights as a function of length. These parameters have been determined for the samples indicated in Table 1, so we can calculate the rate at which biomass was being added to each of the populations represented at the five stations or compare the production of each community for the sampling date. Monthly surveys of nearshore stations, if analyzed in this way can tell us a great deal about the condition of the zooplankton communities in these areas. At present, very few samples exist to allow such analyses. An exception is the data collected for the Davis-Besse power plant survey by DeMott (1976), who calculated seasonal patterns in zooplankton production for 10 stations near Locust Point, Lake Erie. Samples are still being collected from these stations although size frequency measurements are not being done.

David J. Bean, Department of Zoology, Ohio State University, is enumerating eggs and calculating size frequency distributions for 300 samples collected by CCIW from 30 stations in Lake Erie during 1970. He will eventually calculate production estimates for each of these samples. Few of these stations were in nearshore locations, but the point is that nearshore samples collected now may be analyzed later to enable population and biomass dynamics calculations.

Phytoplankton

Due to the inordinate amount of time required to enumerate samples, there are extremely few surveys of phytoplankton done to species for the nearshore zone of Lake Erie. The Davis-Besse project has enumerated phytoplankton in standard plankton net hauls, but few whole water samples have been taken. It is particularly difficult to sample the water column in an integrated way for phytoplankton, and development of sampling techniques in this area are needed. It is probably unreasonable to expect water intake data to represent the real populations of the phytoplankton in the nearshore zone since they represent the algae in a given depth of an occasionally tightly stratified lake. They are of course good indicators of the algal populations which contribute to taste and odor in water supplies, but they are poorer indicators of the overall phytoplankton population as it reflects water quality in the nearshore.

Generation times for phytoplankton are much shorter than those for zooplankton so monthly surveys are even less satisfactory as indicators of phytoplankton populations. Measurements of primary productivity and other physiological measures of algal activity are far superior to simple abundance counts for assessing water quality. The effects of pollution, both thermal and chemical have been examined with respect to primary productivity and can be included in assessment of local impact of micronutrient, toxic material, or thermal loadings. Short-term intensive physiological studies are probably more useful than widely spaced species surveys. At the moment, few data of either kind exist.

Bacteria

In contrast to the above two components of the plankton, bacteriological data abound for the Lake Erie nearshore, both from bathing beaches and from at least 25 intake stations (Beeton & Strand, 1975) providing information on the abundance of fecal coliforms, total coliforms, standard plate counts, and fecal streptococci (Table 2). For these organisms, surveys of known trouble spots can of course be worthwhile, since in absence of any data to the contrary, it can be assumed that all fecal bacteria found in the lake are a result of allochthonous input rather than growth in the lake. Abundance is thus indicative of the process of input less any consumption by the plankton and benthos filter feeders. Data collected by Reitz (1973) indicate improving conditions in the Lake Erie nearshore with respect to anthropogenic bacteria. Any assessment of water quality in the nearshore must include analyses for these bacteria, but the samples should not be limited to water intakes, since these have been placed at zones where bacterial abundance was assumed to be low to begin with. Even those intakes varied tremendously in depth diameter, maximum flow rate, and distance from shore (Table 3).

Literature Cited

Beeton, A. M. and J. W. Strand. 1975. Sources of water quality, lake level, ice, water temperature and meteorological data for the St. Lawrence Great Lakes, Center for Great Lakes Studies, U. of Wisconsin-Milwaukee, Milwaukee, Wisc. Sea Grant Advisory Report No. 10: 169 p.

Boucherle, M., D. A. Culver, and J.W. Fletcher. 1978. Dry weight estimates of biomass for twelve crustacean zooplankton taxa from Lake Erie. Submitted to Oecologia.

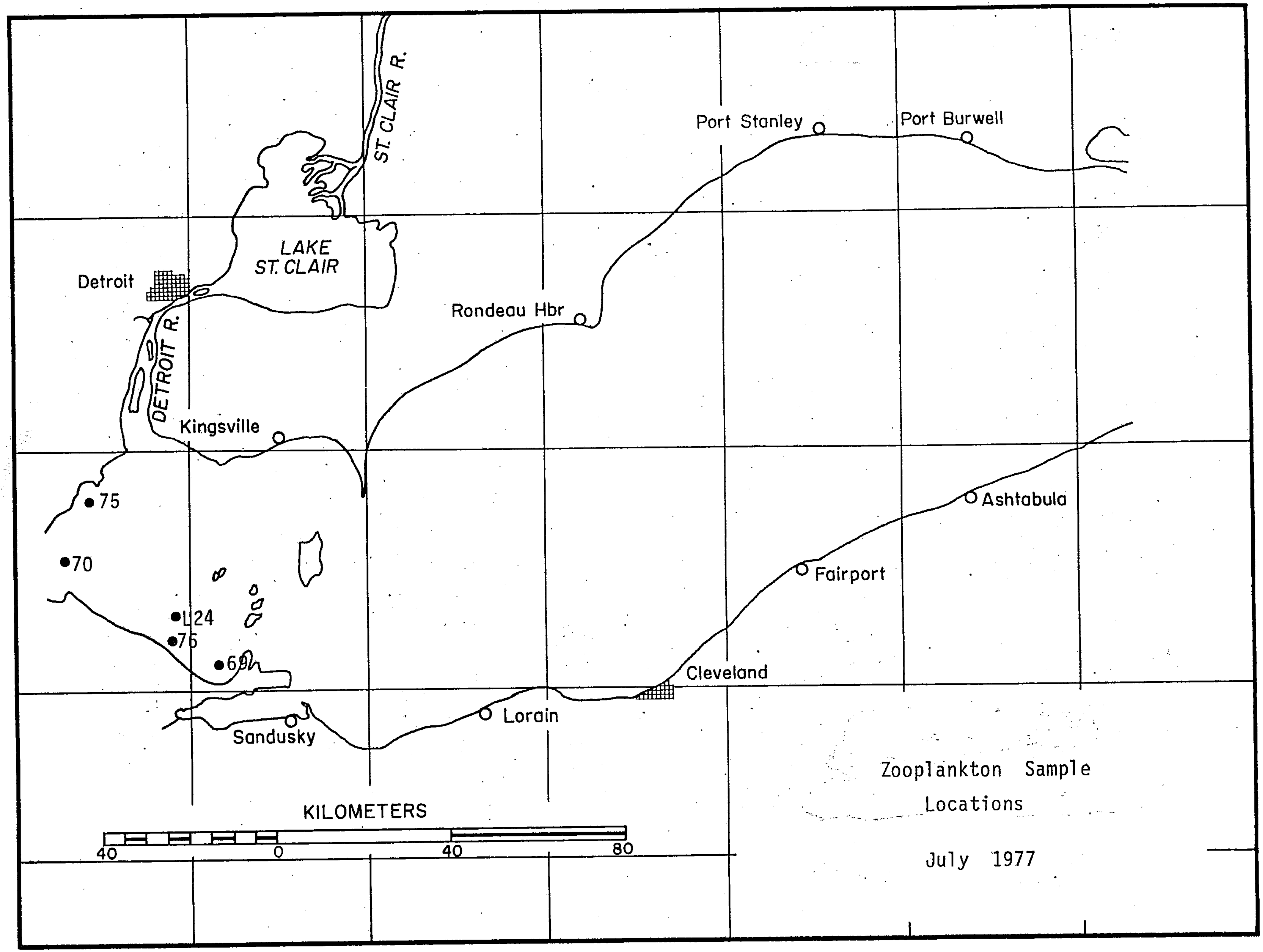
Chengalath, R., C. H. Fernando, and M. G. George. 1972. Planktonic rotifera of Ontario. University of Waterloo Biology Series 2: 40 p.

Culver, D. A. 1978. Productivity calculations for Great Lakes Zooplankton with special reference to lakes Erie and Ontario. (in prep)

DeMott, W. R. 1976. Zooplankton productivity at Locust Point, and inshore area in Western Lake Erie. M. S. thesis, The Ohio State University, Columbus, Ohio. 108 p.

Hall, D. J. 1964. An experimental approach to the dynamics of a natural population of *Daphnia galeata mendotae*. Ecology 45: 94-112.

Reitz, R. D. 1973. Distribution of phytoplankton and coliform bacteria in Lake Erie. Ohio EPA Division of Surveillance Report: 67 p.



Zooplankton Sample Locations

July 1977

TABLE 1

VARIATION IN ABUNDANCE OF ZOOPLANKTON
AT FIVE NEAR-SHORE STATIONS IN LAKE ERIE, JULY 1977.

	STATIONS 69	76	L24	70	75
ROTIFERA					
Asplanchna priodonta	0.37		1.00	0.33	
Keratella cochlearis	0.51		0.67	0.13	
Keratella quadrata				0.21	
Polyarthra sp.	0.14	.004		0.04	
Trichocerca multicrinis	0.46		0.04	0.13	0.03
Trichocerca longiseta				0.04	
COPEPODA					
Diaptomus siciloides males	2.73	0.31	0.38	0.13	0.32
Diaptomus siciloides females	1.85		0.08	0.50	0.45
Diaptomus siciloides copepodids	0.65	0.52	0.08	0.41	0.29
Diaptomus siciloides eggs	13.29			3.83	0.71
Calanoid nauplii	4.21		0.71	0.13	0.22
Cyclops bicuspidatus thomasi females	0.14				
Cyclops vernalis males	0.23	0.42	0.83	0.63	1.22
Cyclops vernalis females	3.10	2.08	1.33	0.58	2.50
Cyclops vernalis copepodids	0.28	0.63	0.33	2.17	0.83
Cyclops vernalis eggs		14.74		4.75	4.78
Cyclopoid nauplii	0.74	0.10	1.63	12.63	1.25
CLADOCERA					
Chydorus sphaericus non-ovigerous	0.14	1.77	0.21	4.00	0.35
Chydorus sphaericus ovigerous	0.14	0.47	0.04	19.33	0.19
Chydorus sphaericus eggs	0.14	0.63	0.08	6.92	0.19
Daphnia galeata mendotae non-ovigerous	11.67	4.22	7.13	0.04	0.03
Daphnia galeata mendotae ovigerous	0.60	0.10	0.38		
Daphnia galeata mendotae eggs	1.48	0.26	0.67		
Daphnia retrocurva non-ovigerous	3.98	21.15	0.13	6.54	1.31
Daphnia retrocurva ovigerous	0.09	0.52		0.96	0.29
Daphnia retrocurva eggs	0.14	0.125		2.08	0.45

TABLE 1 (CON'T)

VARIATION IN ABUNDANCE OF ZOOPLANKTON
AT FIVE NEAR-SHORE STATIONS IN LAKE ERIE, JULY 1977

CLADOCERA	STATIONS 69	76	L24	70	75
Diaphanosoma leuchtenbergianum non-ovigerous	0.28	0.10	0.04	0.75	0.16
Diaphanosoma leuchtenbergianum ovigerous				0.04	0.03
Diaphanosoma leuchtenbergianum eggs				0.04	0.16
Eubosmina coregoni non-ovigerous	1.16	1.51	0.50	9.46	1.31
Eubosmina coregoni ovigerous	0.14	0.10	0.08	4.13	0.58
Eubosmina coregoni eggs	0.14	0.10	0.13	5.96	0.81
Leptodora kindtii non-ovigerous	0.08	0.66			
Alona affinis non-ovigerous		0.42	0.04		0.22
Alona affinis ovigerous					0.03
Alona affinis eggs					0.03

Note: Data are broken down by species, developmental stages, and numbers of eggs, all in numbers per liter of lake water.

TABLE 2

AVAILABLE NEARSHORE WATER QUALITY DATA-
LAKE ERIE WATER INTAKES

No.	Data Source	Water Intake Source	Type of Data			Period of Record	Availability
			Phyto.	Zoopl.	Bacteria		
1	Joseph D. D'Haene City of Monroe Michigan Water Dept. 915 E. Front St. (313)241-5947	(1) 30" 5200 22' 6 MGD			T.Co.	? (D)	Y
2	R. W. Downing Ford Motor Co. 3200 E. Elm Ave. Monroe, Mich. 48161 (313)241-6600 Ex. 277	(1) 95' 5,280' inland 20' 10 MGD			T.Co.	? (D)	
3	William Lunsford Consolidated Packaging Corp. 921 E. Elm Ave. Monroe, Mich. 48161 (313)241-9000	(2) 24" 5280' 12' 8 MGD			T.Co.	June 1971- Jan. 1973 (W)	Y
4	Richard R. Henderson City of Toledo 600 Collins Park Ave. Toledo, Ohio 43605	(1) 83' 10,560' 20' 80 MGD			T.Co., S.P.C. F.Co.	Jan. 1942-Pres. (D, H, C) Jan. 1972-Pres. (D,W)	Y

TABLE 2

AVAILABLE NEARSHORE WATER QUALITY DATA-
LAKE ERIE WATER INTAKES

No.	Data Source	Water Intake Source	Type of Data			Period of Record	Availability
			Phyto.	Zoopl.	Bacteria		
5	Lowell Roe Toledo Edison 300 Madison Ave. Toledo, Ohio 43652 (419)259-5242 for Davis-Besse station	(1) 8" 2500' 10' 0, 01 MGD			T.Co.	1971-Pres. (M)	Y S.S.
6	Donald Held Port Clinton Water Works 205 E. Perry St. Port Clinton, Ohio 43452 (419)734-4040	(1) ? 2500' 14' 1.5 MGD			F.Co. T.Co.	Aug. 1973-Pres. (D) ? (D)	
7	Howard Ostling Erie Industrial Park P.O. Box 118 Port Clinton, Ohio 43452 (419)732-2151	(1) 12" 4350' 17' 0.4 MGD			T.Co.	1967-Pres. (H, W)	Y
8	George A. Butts Sandusky Water Works 2425 1st Street Sandusky, Ohio 44870 (419)625-5676	(2) 42", 36" 2800' 20' 11 MGD			T.Co. F.Co. F.S.	1964-Pres. (D, C) 1973-Pres.(D) 1973-Pres.(D)	Y S.S.

TABLE 2

AVAILABLE NEARSHORE WATER QUALITY DATA-
LAKE ERIE WATER INTAKES

No.	Data Source	Water Intake Source	Type of Data			Period of Record	Availability
			Phyto.	Zoopl.	Bacteria		
9	L.A. Pursell United States Gypsum Gypsum, Ohio 43433 (419)734-3161	(1) 14" 600' 6, 5' 1, 6 MGD			T.Co., F.Co.	May-Aug. 1971 (W)	Y
10	Scott R. Hetrick Huron Dept. of Utilities City Hall Huron, Ohio 44839 (419)433-4125	(1) ? 2000' ? 1, 3 MGD			T.Co. F.Co.	1958-Pres. (D) 1972-Pres. (D)	Y
11	C.E. Emerick Lorain Water Treatment 1106 1st Street Lorain, Ohio 44052 (216)244-3135	(1) 48" 2780' 31' 13, 8 MGD			F.Co, F.S. T.Co.	1968-Pres.(M,W,D) 1907-1908, 1947-Pres. (D)	Y S.S.
12	John W. Kniepper Avon Lake Municipal Utilities Dept. 33370 Lake Rd. Avon Lake, Ohio 44012	(1) 36" 2000' 22' 4, 2 MGD			T.Co. F.Co. F.S.	1961-Pres. (D, P, W, 2XM) 1970-Pres.(W,D) 1971-Pres. (D)	Y

TABLE 2

AVAILABLE NEARSHORE WATER QUALITY DATA-
LAKE ERIE WATER INTAKES

No.	Data Source	Water Intake Source	Type of Data			Period of Record	Availability
			Phyto.	Zoopl.	Bacteria		
13	James H. Jefferies Cleveland Div. Of Water and Heat Baldwin Filtration Plant 11216 Fairhill Rd. Cleveland, Ohio 44104 (216)694-3192	(1) 9' 26, 147' 27' 110 MGD			T.Co., S.P.C., F.Co., F.S.	1926-Pres.(M,D) 1972-Pres. (D) 1973-Pres. (M, Q, 2XW)	Y
14	James H. Jefferies Cleveland Div. of Water and Heat Nottingham Filtration Plant 1300 Chardon Rd. Cleveland, Ohio 44117 (216)694-3192	(1) 8' 3.5 Miles 40' 115 MGD			T.Co. S.P.C. F.S. F.Co.	1951-Pres.(D,M,W) 1973-Pres.(M,Q,2XW) 1972-Pres. (D)	
15	James H. Jefferies Cleveland Div. of Water and Heat Crown Filtration Plant 955 Clague Rd. West Lake, Ohio (216)694-3192	(1) 8' 2.5 Miles 40' 45 MGD			T.Co. S.P.C. F.S. F.Co.	1958-Pres.(M,D,W) 1973-Pres.(M,Q,2XW) 1972-Pres. (D)	

TABLE 2

AVAILABLE NEARSHORE WATER QUALITY DATA-
LAKE ERIE WATER INTAKES

No.	Data Source	Water Intake Source	Type of Data			Period of Record	Availability
			Phyto.	Zoopl.	Bacteria		
16	Thomas R. Johnson Ohio Water Service Twilight Dr. Mentor-on-the-lake, Ohio 44060 (216)257-6190	(1) ? 2,400' 19' 6 MGD			T.Co. F.Co. S.P.C.	1958-Pres. (D) 1973-Pres. (2XW,2XM) 1963-1972 (D)	Y
17	Robert Stalker Painesville Water Plant Richmond St. Painesville, Ohio 44077 (216)257-1311	(1) ? 800' 12' 4 MGD			T.Co. F.Co.	1939-Pres. (D) 1973-Pres. (D)	Y S.S.
18	E.H. Knape IRC Fiber Company 750 Bacon Rd. Painesville, Ohio 44077 (216)354-4321	(1) 48" 4000' 21' 4 MGD			F.S. T.Co.	1973-Pres. (M,W) 1951-Pres. (D,W)	No
19	Kaizor M. Chatriwalla Ohio Water Service Co. Green Rd. Plant Madison-on-the-Lake Ohio 44057 (216)428-2373	(1) 24" 2000' 28' 1, 2 MGD			T.Co. F.Co.	1972-Pres. (D)	Y

TABLE 2

AVAILABLE NEARSHORE WATER QUALITY DATA-
LAKE ERIE WATER INTAKES

No.	Data Source	Water Intake Source	Type of Data			Period of Record	Availability
			Phyto.	Zoopl.	Bacteria		
20	Edgar A. Coates Conneaut Water 770 Lake Rd. Conneaut, Ohio 44030 (216)593-1508	(1) 24" 1900' 36' 2, 2 MGD			T.Co. F.Co.	1958-Pres. (D)	Y
21	Stanley J. Prazer City of Erie Bureau of Water Foot of Chestnut St. Erie, Pa. 16507 (814)8561, Ex.324-317	(2) 60", 72" 1.25 Miles 26' 50 MGD			T.Co., S.P.C. F.Co.,	1914-Pres. (D) 1972-Pres. (D)	Y
22	James O'Conner Dunkirk Water Dept. Dunkirk, N.Y. 14048 (716)366-3755	(1) 36" 1240' 34' 4.7 MGD			T.Co. F.Co., F.S.	1947-Pres.(D,H,W) ? (P)	Y S.S.
23	Robert G. O'Conner City of Buffalo Buffalo, N.Y. (716)886-1404, Ex.56	(2) 110', 70' 6651' 62' 125 MGD			T.Co., S.P.C.	1926-Pres.(P,D)	Y S.S.