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ENVIRONMENTAL STRESSES ON BENTHIC ORGANISMS (OSTRACODA) WITHIN LAKE ERIE

L.D. Delorme

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ABSTRACT

Sediment samples collected from the sediment-water interface from Lake Erie in 1975 indicate the presence of a few live shelled invertebrates (ostracodes). Of the 26 species identified only one, *Candona caudata*, can be considered as successful today in Lake Erie. *Cytherissa lacustris* and *Candona subtriangulata*, primarily recovered as empty shells in this study, indicate that these species have become extinct because of a chemical and/or physical change some time during the last 100 years in Lake Erie. Dissolved oxygen stress patterns verify the oxygen depletion pattern noted by Burns and Ross (1972) and indicate its existence for some time in the central basin.

INTRODUCTION

General. Modern ostracodes have been studied from localized areas within Lake Erie. Furtos, 1933, studied the ostracode fauna from weedy inlets, stony bars and rock pools, all at depths of less than 25 feet in the vicinity of the Bass Islands. Delorme (1977a) identified the ostracode fauna between Port Glasgow to Point Pelee in conjunction with a sediment survey by St. Jacques and Rukavina (1976). Benson and MacDonald (1963) studied fossil ostracodes from several cores obtained from the central and eastern basins.

The ostracode (seed shrimp) is a benthic or semi-nektonic organism which feeds on organic detritus. Those that are semi-nektonic crawl on or swim around plants, feeding on the plants as well as organic detritus. Those that are benthic forms crawl on or burrow into the bottom sediment (down to 2 cm) and feed on organic detritus. The different species can tolerate very different concentrations of chemical components in the water.

In order to determine the physical and chemical characteristics of the aquatic habitat that a particular ostracode species occupy, the author has, during the years 1965 to 1976, sampled 6,720 stations across Canada. These autecological data are presented here for the three species to be discussed (Tables 2, 3, 4).

Method of collection and preparation. During September of 1975, Dr. C.I. Dell collected sediment samples from the sediment-water interface of Lake Erie, for sedimentological and mineralogical analyses. Of the four Shipek grab samples obtained from each of the 150 stations, one was used for the study of mineralogy and shelled invertebrates. The sediment was wet-sieved immediately after sampling using large diameter sieves retaining all fractions greater than 63 microns. The residue was oven-dried and then dry-sieved into fractions of >2000 microns, 200 to 250 μ, and 250 to 63 μ. Prior to wet-sieving of the samples, the water which remained in the Shipek bucket was decanted. Free-floating or non-attached organisms were probably lost at this time. Also, a pressure wave may precede the Shipek sampler if lowered rapidly, thereby sweeping away some of the semi-nektonic organisms and the organic floc above the mud-water interface, as has been described by Sly (1969) and Brinkhurst (1967).

For each sample studied, the state of life for each species was recorded as live or fossil (empty shell). Twenty-percent of the stations contained live specimens. Of all the specimens collected 14 percent were alive with half of these belonging to the species *Candona caudata*. The identification of the species for each sample is given in Delorme (1977b). Table 1 lists the ostracode species recovered during the 1975 cruise. See appendix I for a complete listing of ostracode species by station. Appendix II contains the geographical coordinates for the stations.

Species	Life Cycle*	Relative Occurrence Western Basin	Central Basin	Eastern Basin
Candona caudata	M	62%	80%	86%
Physocypria globula	M	50%	9%	47%
Isocypris quadrisetosa	M	42%	10%	41%
Candona acuta	M	42%	3%	
Candona eriensis	Y?	42%	1%	14%
Darwinula stevensoni	M	42%		
Physocypria inflata	Y?	38%	3%	7%
Cypridopsis vidua	M	15%	4%	21%
Candona rawsoni	M	15%	6%	47%
Candona elliptica	M	12%		
Cytherissa lacustris	Y	12%	60%	69%
Limnocythere verrucosa	Y	12%	3%	14%
Limnocythere sp.	Y	12%	4%	24%
Physocypria pustulosa	M	4%		
Candona truncata	?	4%		
Candona intermedia	M	4%	7%	
Candona crogmaniana	M		24%	48%
Candona candida	M		6%	17%
Candona faba	?		3%	38%
Limnocythere friabilis	Y		4%	31%
Cypria ophthalmica	M			3%
Candona subtriangulata	Y			55%
Ilyocypris bradyi	M			7%
Limnocythere inopinata	M			3%
Limnocythere ornata	Y			3%
Limnocythere pseudoreticulata	M			10%

Table 1. Relative occurrence of ostracode species within the three basins regardless of state of life.

* M — life cycle in terms of weeks to several months.

Y — life cycle in terms of one year.

DISTRIBUTION OF OSTRACODE SPECIES AND SPECIES LIMITATIONS

Western Basin. Of the 26 ostracode species found in the Lake Erie sediments, only 16 are represented in the western basin. As there were only four littoral (where the euphotic zone intersects the substrate of the shore zone) samples collected in this basin, those species whose relative occurrence is less than 15% are either littoral species or deeper water forms which have a small chance of occurring in a shallow basin. This leaves seven species which can be considered typical of the western basin during the recent past.

Darwinula stevensoni appears to be restricted to the western basin (Fig. 1), however, from samples collected for a detailed sedimentological survey east of Point Pelee, by St. Jacques and Rukavina (1976), Delorme (1977b) identified this species from a part of the north shore of the central basin. Of all the forms, *Candona caudata* can be considered cosmopolitan, not only for the western basin, but for the whole lake (Fig. 2). The closely related forms, *Physocypria globula* (Fig. 3) and *P. inflata*, are common to the western basin; both forms are commonly found at depths below ten meters. *Physocypria inflata* is not found where the bottom water oxygen concentrations go below 7 mg/l (author's unpublished autecological data). *Isocypris quadrisetosa*, although not restricted to the western basin, is most commonly found in the area around the islands between Point Pelee and Sandusky (Fig. 4). This species prefers warm waters above 16°C and oxygen concentrations above 5 mg/l (author's unpublished autecological data); in terms of a modern analogue, it is frequently found in the shallow

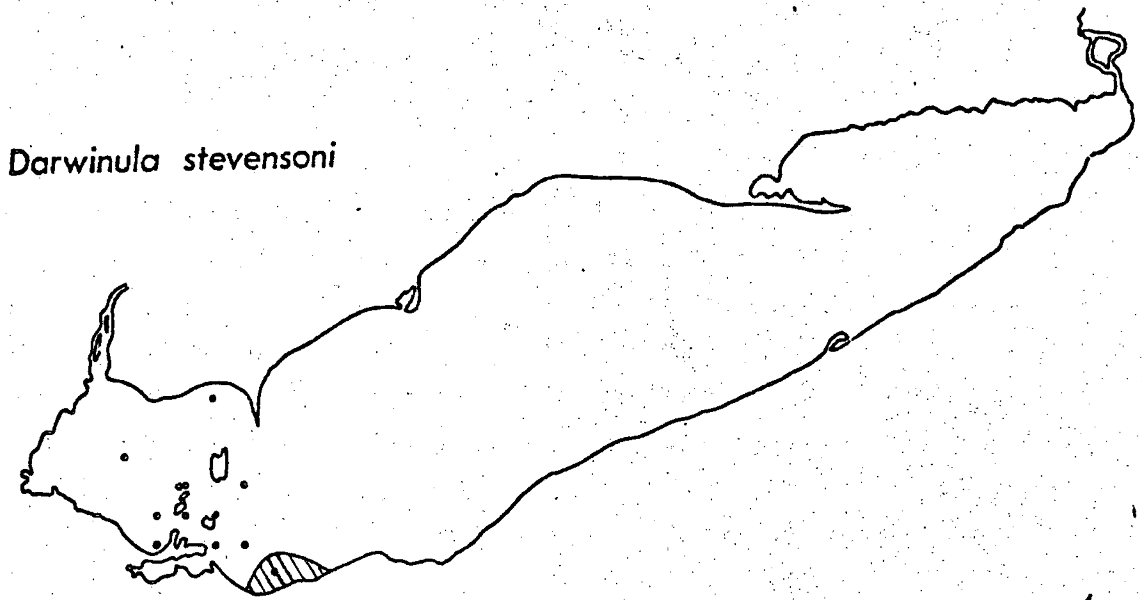

Figure 1. Distribution of *Darwinula stevensoni* in lake Erie (1975).

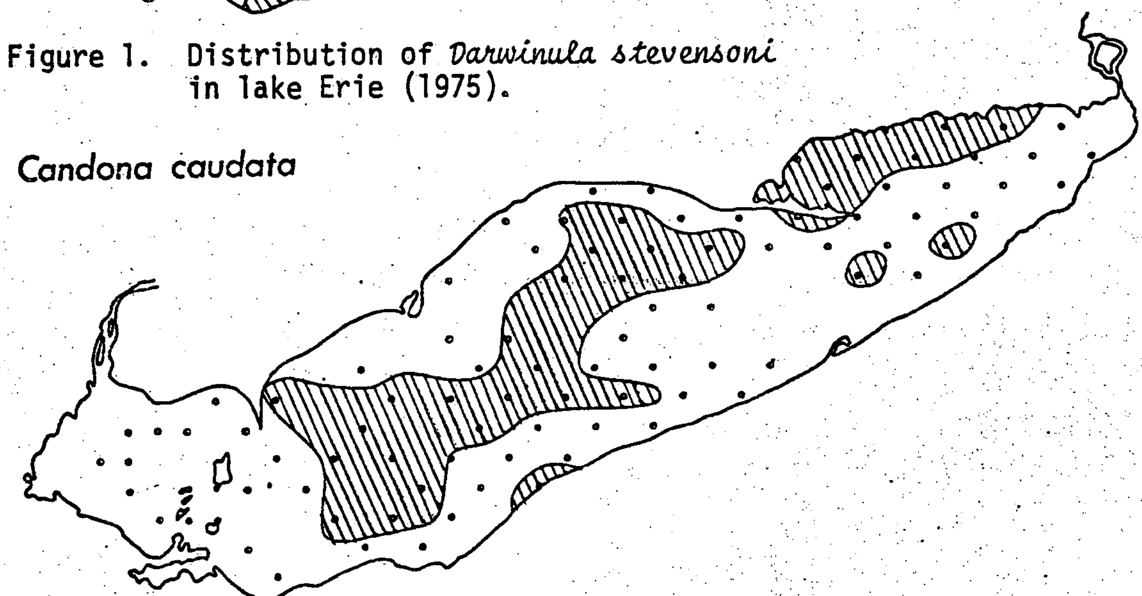

Figure 2. Distribution of *Candona caudata* in Lake Erie (1975).

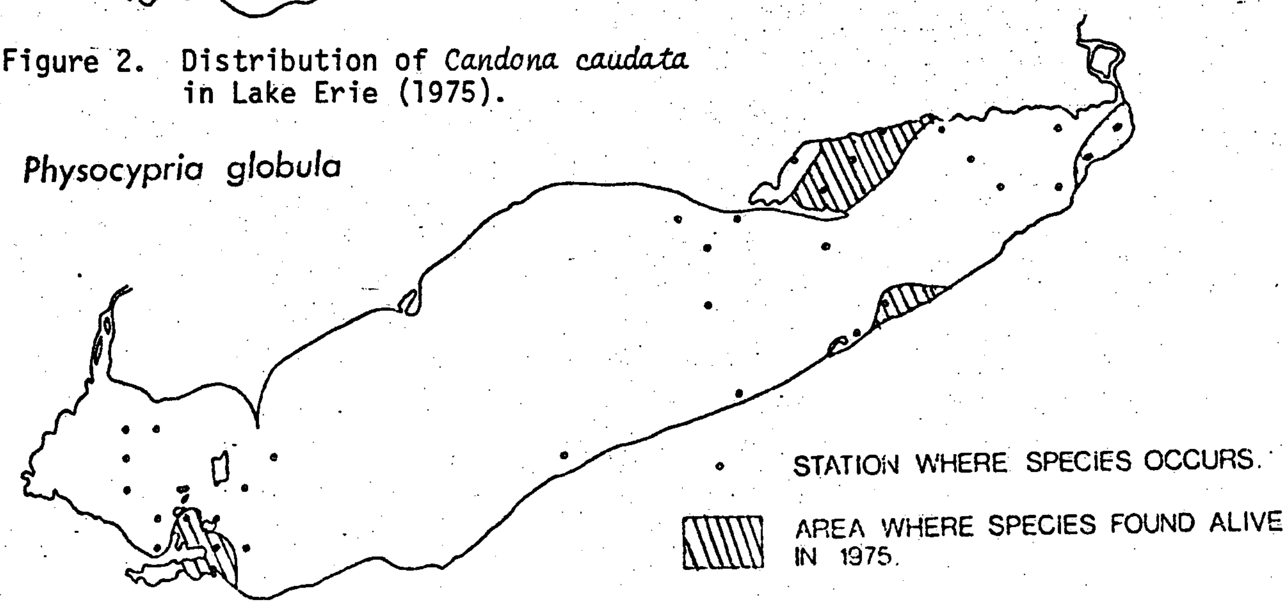

Figure 3. Distribution of *Physocypria globula* in Lake Erie (1975).

Isocypris quadrisetosa

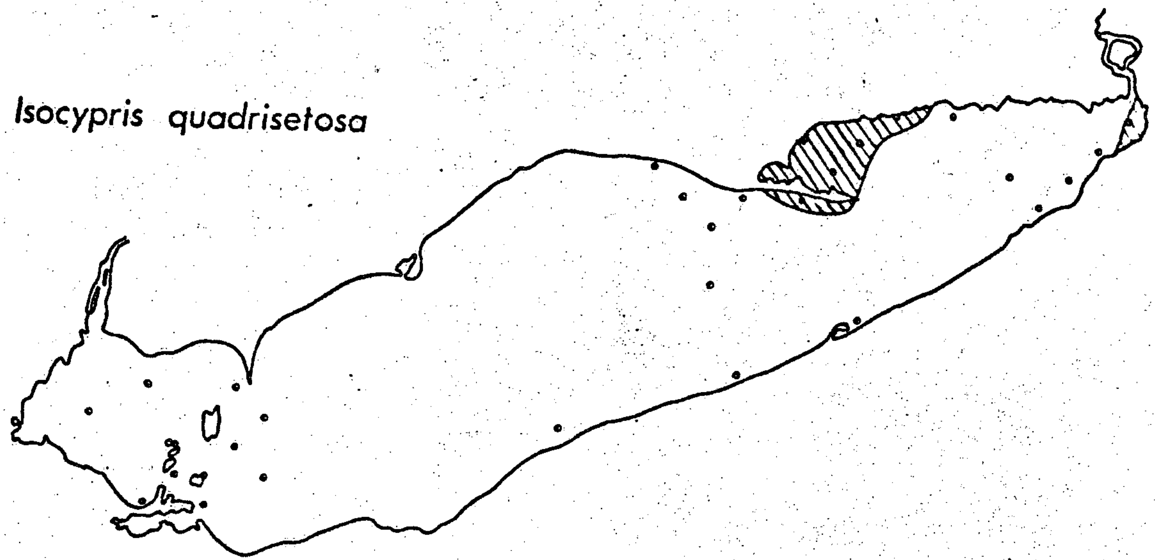

Figure 4. Distribution of *Isocypris quadrisetosa* in Lake Erie (1975).

Candona acuta

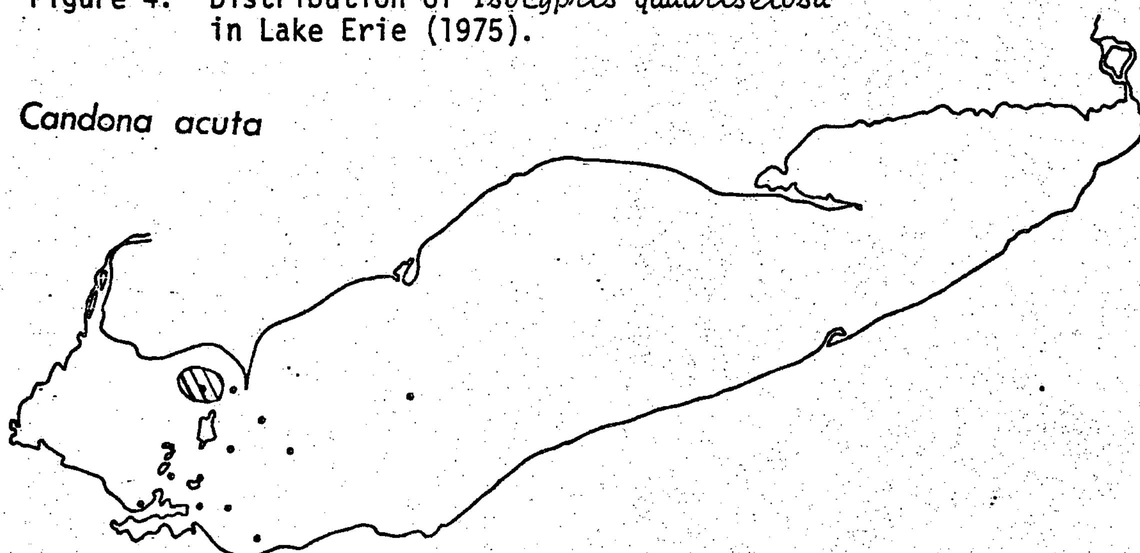

Figure 5. Distribution of *Candona acuta* in Lake Erie (1975).

Cytherissa lacustris

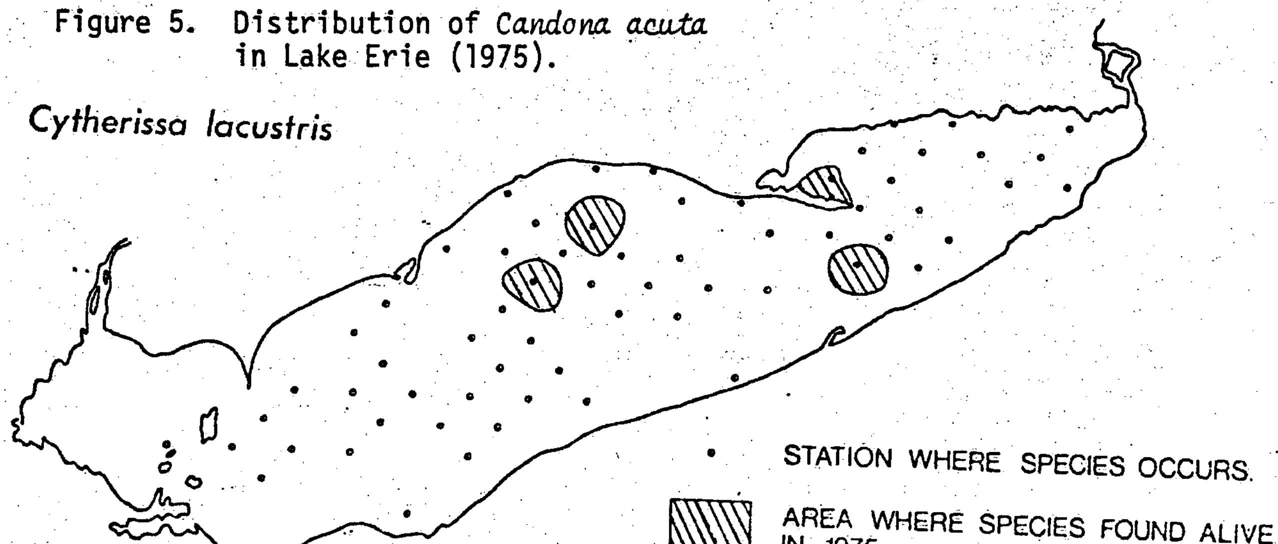

Figure 6. Distribution of *Cytherissa lacustris* in Lake Erie (1975).

bays of the Bay of Quinte (Delorme, 1977a). *Candona acuta* is a common fluvial species, but is also found in ponds and lakes. Its distribution in the western basin (Fig. 5) during the recent past follows the pathways of current activity. The absence of this species from the central and eastern basin is a product of depths exceeding nine meters. It can tolerate dissolved oxygen concentrations as low as 2.5 mg/l (author's unpublished autecological data). *Candona eriensis*, although common to the western basin, is not restricted to it.

Central Basin. Sixteen ostracode species were recovered from the surface sediments of this basin, out of a possible total of 26 (see table 1). Three species can be considered typical of the central basin, the other forms with a relative occurrence of less than 10% are either littoral species or ostracodes that could not become successful because of some limiting factor(s).

Candona caudata, as previously pointed out, is cosmopolitan for the lake. Figure 2 illustrates that 31% of the stations contained live specimens of this species. No other species occurred in the live state in such high abundance. Anatomically, *Candona caudata* is completely devoid of any swimming power and, therefore, lives on or in the substrate; consequently, it was retained in the samples when the water was decanted. It should be pointed out that the species can tolerate dissolved oxygen as low as 2.3 mg/l (table 2). The minimum oxygen concentrations during September 1975 varied from 1.8 to 8.2 mg/l for the central basin (STORET); however, Lucas and Thomas (1972) indicate values as low as 0 mg/l for the beginning of September 1970. Autecological studies by the author (table 1) show this species to be a

Parameter	Minimum	Maximum
Bottom Water Temperature	3.4	27.0°C
Surface Water Temperature	2.2	27.0°C
Depth	0.15	189 meters
Calcium	4.0	180.0 mg/l
Magnesium	0.0	292.8 mg/l
Potassium	0.1	32.0 mg/l
Sodium	0.4	325.0 mg/l
Copper	0.0	1.5 mg/l
Dissolved iron	0.0	6.0 mg/l
Carbon dioxide	0.0	10.0 mg/l
Dissolved oxygen	2.3	14.0 mg/l
Bicarbonate	17.1	645.4 mg/l
Carbonate	0.0	180.0 mg/l
Chloride	0.6	70.0 mg/l
Sulphate	0.0	1350.0 mg/l
Orthophosphate	0.0	1.6 mg/l
pH	5.2	9.4
Total Dissolved Solids	20.6	2054.1 mg/l
Conductivity	34.0	1800.0 µmhos

Table 2. Autecology of *Candona caudata* based on 485 sampled stations collected by the author from Canada.

common inhabitant of temporary ponds and intermittent streams, thereby precluding a long life cycle. Undoubtedly, several generations of eggs are produced per year, allowing the species to propagate itself despite the development of anoxic conditions during the fall. Unhatched eggs that remain can survive anoxia and propagate the species at some later time when anoxic conditions have disappeared.

Cytherissa lacustris is generally considered to be a deep, cold water form. However, the species lives within a temperature range of 3.7 to 22.0°C and a depth range of 0.6 to 181 meters (table 3). Therefore, the generalization does not appear to be true. As compared to the previous species, C. *lacustris* also lacks swimming power and, using the same reasoning as above, the species should have been present in the live state in the samples (Fig. 6). An examination of autecological data (table 3) for the species indicates that the species is only found in permanent lakes, and has a life cycle which either approaches or exceeds one year. This being the case, *Cytherissa lacustris* could have been brought to local extinction by its requirement for minimal dissolved oxygen content of 3.0 mg/l. Other parameters which this species finds particularly limiting are copper, dissolved iron, orthophosphate and pH.

Candona crogmaniana is still poorly understood with respect to its autecology. The only area, of those investigated for the Great Lakes, in which the species appears to be successful is Parry Sound of Georgian Bay, Lake Huron (Delorme, 1976). Unfortunately, there is no information on the chemical and physical habitat in which the species was found for that study. Autecological data that are available (author's unpublished data) indicate the species is probably limited by copper, dissolved iron, orthophosphate and pH. The species is only moderately affected by low oxygen concentrations,

Parameter	Minimum	Maximum
Bottom Water Temperature	3.7	23.0°C
Surface Water Temperature	5.0	25.2°C
Depth	0.6	181.4 meters
Calcium	2.0	49.6 mg/l
Magnesium	0.0	16.7 mg/l
Potassium	0.0	21.6 mg/l
Sodium	0.3	30.7 mg/l
Copper	0.01	0.4 mg/l
Dissolved iron	0.0	3.9 mg/l
Carbon dioxide	0.0	10.0 mg/l
Dissolved oxygen	3.0	13.4 mg/l
Bicarbonate	3.7	183.0 mg/l
Carbonate	0.0	14.4 mg/l
Chloride	1.6	33.0 mg/l
Sulphate	1.0	55.0 mg/l
Orthophosphate	0.0	0.5 mg/l
pH	6.4	8.8
Total Dissolved Solids	11.2	215.0 mg/l
Conductivity	25.0	370.0 µmhos

Table 3. Autecology of *Cytherissa lacustris* based on 281 sampled stations collected by the author from Canada.

having a lower limit (so far determined) of 2.3 mg/l. In many respects, *Candona crogmaniana* appears to have similar requirements to *Cytherissa lacustris*, except that its distribution in the central basin is more limited (Fig. 7) to the repositories or sinks of the prevailing bottom currents (Herdendorf, 1977).

It is important to assess the minor faunal elements as well as the three typical forms discussed above. Of the 13 remaining species, six are known (from the author's unpublished data) to frequent habitats at depths greater than 15 meters. These are: *Physocypria globula*, *Candona rawsoni*, *Cypridopsis vidua*, *Limnocythere* sp., *Limnocythere friabilis*, and *Physocypria inflata*. Based on a statistical evaluation of autecological parameters carried out by Delorme and El-Shaarawi (1977), it is possible to calculate the sample size required to obtain a precision of the mean value within ten percent, using the estimate of the variance. Using this technique, it was found that copper, dissolved iron, dissolved oxygen, orthophosphate and pH are all common limiting factors of both the shallow and deep water species. All of these parameters are the same ones found limiting the three typical species of the basin. Because the chemistry of the water prevailing at the time these organisms lived is not known, it is not possible to say which of the five, or combination of these, exerted sufficient stress to cause the ostracodes to become locally restricted or extinct, if indeed they are no longer in existence.

Eastern Basin. Twenty out of a total of 26 ostracodes species were identified in the surface samples. Twelve species of the 20 can be considered typical of the eastern basin or to have a relative occurrence of greater than 21 percent (see table 1). Of the 12, three can be further considered to

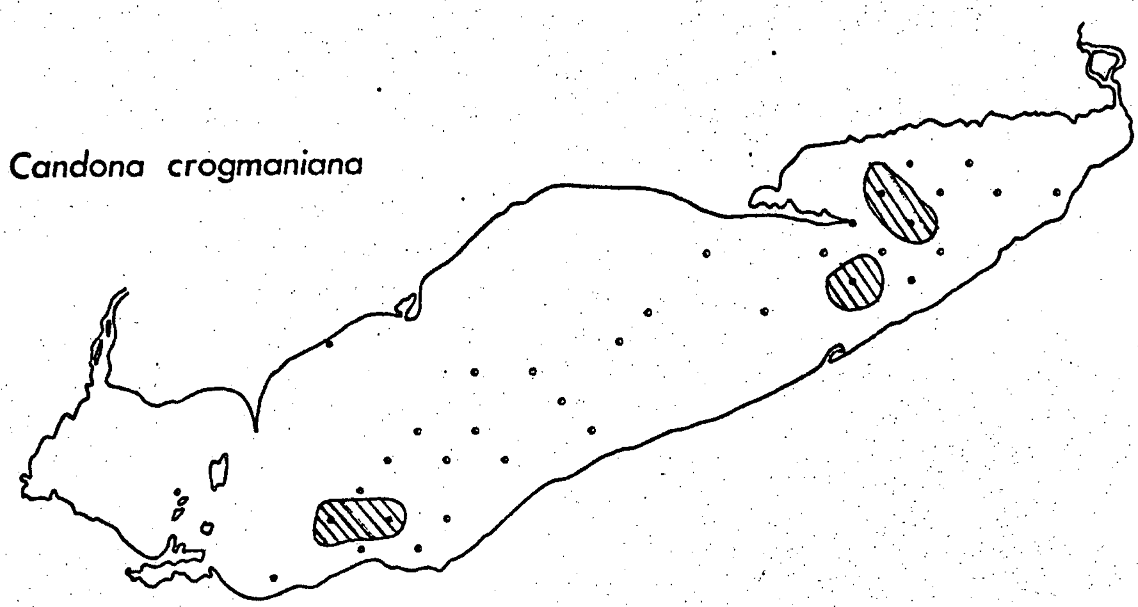

Figure 7. Distribution of *Candona crogmaniana* in Lake Erie (1975).

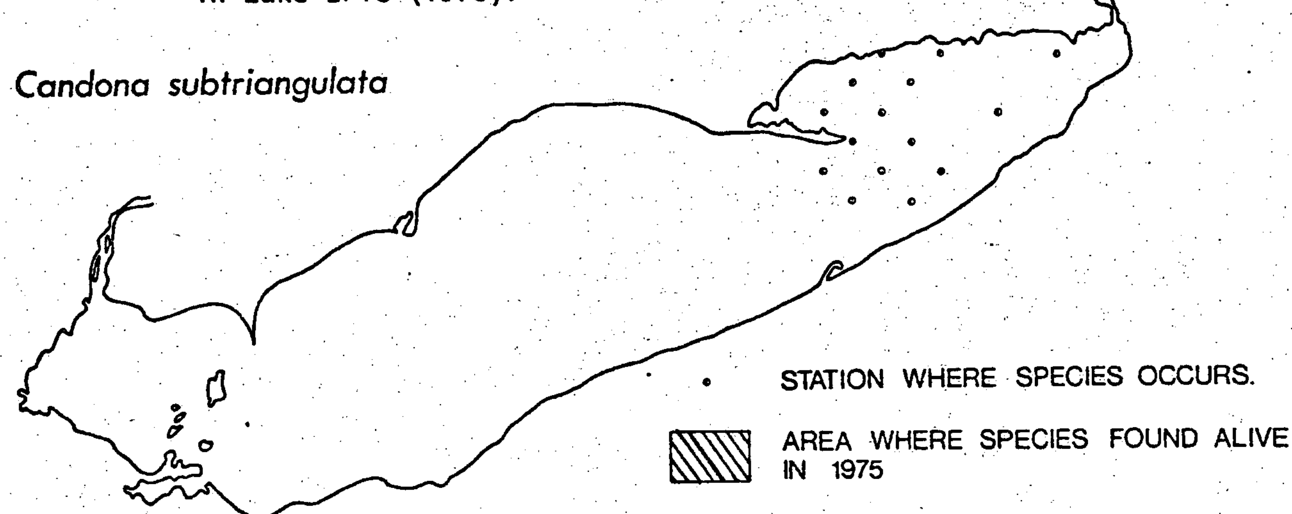

Figure 8. Distribution of *Candona subtriangulata* in Lake Erie (1975).

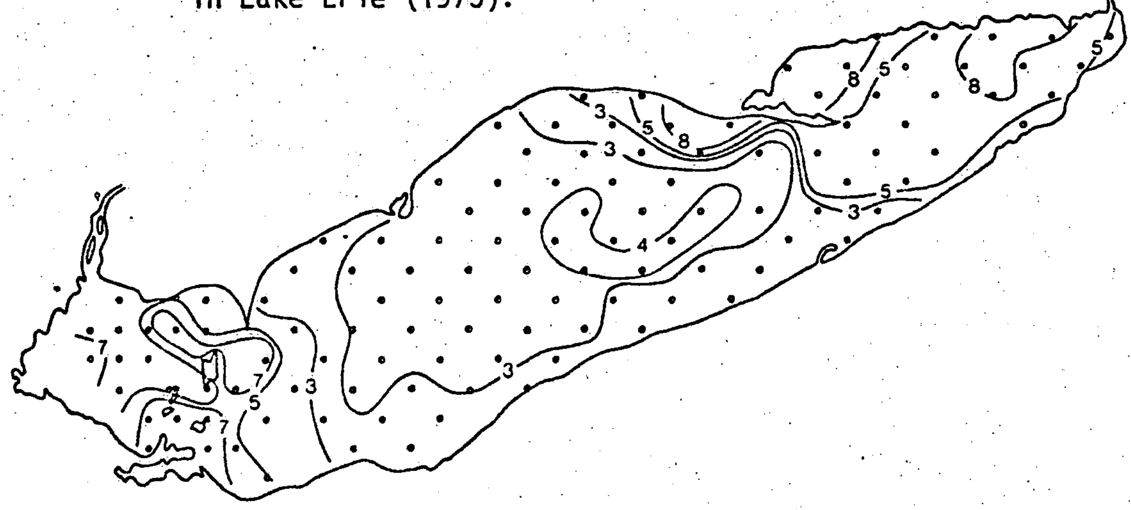

Figure 9. Minimum dissolved oxygen requirement for the survival of ostracode species recovered from the sediment-water interface of Lake Erie.

be typical abyssal species occurring at depths greater than 20 meters. These are *Candona subtriangulata*, *Cytherissa lacustris* and *Candona crogmaniana*, exclusive of the cosmopolitan *Candona caudata*. The disposition of *Cytherissa lacustris* and *Candona crogmaniana* have already been dealt with within the discussion of the central basin, as has *Candona caudata*.

Candona subtriangulata is characteristic of the eastern basin, being restricted to it during the recent past (Fig. 8). At first glance, it would appear that depth controls the species to the eastern basin. Studies of the bottom fauna of the eastern end of Lake Superior (Delorme, 1977c) indicate that *C. subtriangulata* has a depth range of 7.6 to 273 meters (table 4). If depth were the single controlling factor, this species would then exist in the central basin and perhaps even the western basin (maximum depth 10 meters), as indeed it has in prehistorical times (Benson and MacDonald, 1963). An analysis of autecological data (table 4) indicates that the species is severely limited to low concentrations of 11 parameters. These are copper, dissolved iron, magnesium, potassium, sodium, dissolved oxygen, chloride, orthophosphate, pH and total dissolved solids (and conductance). Clearly, low concentrations of magnesium, potassium, sodium and chloride contribute to low concentrations of total dissolved solids required or tolerated by the organism. Burns and Ross (1972) have indicated an increase in the concentration of dissolved iron (up to 6.21 μmoles/l) and manganese just above the sediment-water interface when the surface sediments become strongly reducing. If the levels of dissolved iron exceeded 500 ppb (9.0 μmoles/l of Fe) or 300 ppb for copper, then *Candona subtriangulata* would not be able to survive. When such a reduction of the sediments occur, there is a corresponding decrease in dissolved oxygen which, if decreased below 5.6 mg/l, would be detrimental to the species.

Parameter	Minimum	Maximum
Bottom Water Temperature	2.6	19.2°C
Surface Water Temperature	2.2	28.0°C
Depth	7.6	273.1 meters
Calcium	3.3	22.5 mg/l
Magnesium	0.7	7.5 mg/l
Potassium	0.0	1.2 mg/l
Sodium	1.0	4.3 mg/l
Copper	0.01	0.3 mg/l
Dissolved iron	0.0	0.5 mg/l
Carbon dioxide	0.8	12.0 mg/l
Dissolved oxygen	5.6	13.4 mg/l
Bicarbonate	8.5	97.6 mg/l
Carbonate	0.0	0.0 mg/l
Chloride	1.2	7.8 mg/l
Sulphate	0.0	12.0 mg/l
Orthophosphate	0.0	0.5 mg/l
pH	6.1	8.1
Total Dissolved Solids	22.9	92.3 mg/l
Conductivity	44.0	106.0 μmhos

Table 4. Autecology of *Candona subtriangulata* based on 46 sampled stations collected by the author from Canada.

Clearly, oxygen values of lower than 5.6 mg/l have frequently been attained by the western and central basins, thereby causing extinction because the species has a life cycle which approaches or exceeds one year in duration (Fig. 1). Consequently, successive generations were impeded from developing because of recurring conditions of low-oxygen concentration. Although the eastern basin is not considered to become anoxic, dissolved oxygen concentrations as low as 1.6 mg/l for certain areas of the basin have been observed (Burns et al., 1976). This would be sufficient to cause an annual extinction of *Candona subtriangulata*. If these low values recurred on an annual basis, then the species would have become extinct, however, it probably has not yet occurred on a basin-wide basis.

Of the minor-faunal elements, *Candona eriensis*, *Limnocythere verrucosa*, *Candona candida*, *Cypria ophthalmica*, *Ilyocypris bradyi*, *Limnocythere inopinata*, *Limnocythere ornata* and *Limnocythere pseudoreticulata* are species found at depths less than nine metres. Many of these are fluvial in origin and either existed in or on a deltaic habitat, or the empty shells were transported by streams and deposited as part of the deltaic sediments. The remaining ostracodes (*Physocypria globula*, *Isocypris quadrisetosa*, *Physocypris inflata*, *Cypridopsos vidua*, *Candona rawsoni*, *Limnocythere* sp., *Limnocythere friabilis* and *Candona faba*) are those which can live to depths of 30 meters. Using the same technique as outlined above (Delorme and El-Shaarawi, 1977), it was found (based on the author's unpublished autecological data) that the following common parameters are tolerated in low concentrations by the 16 species: dissolved iron, copper, dissolved oxygen, orthophosphates and pH. These are similar to the ones described for the typical abyssal ostracode species.

<u>Summary</u>. If one were to plot the minimum tolerable dissolved oxygen level acceptable for an ostracode faunal assemblage for each sample collected (see appendix III), then a pattern would emerge for Lake Erie (Fig. 9). A minimum of 3 mg/l (or higher levels) of dissolved oxygen must have been maintained throughout the year for the survival of *Cytherissa lacustris*, the most tolerant species, of the assemblage, to reduced oxygen levels. This is certainly not the case at the present time, with the development of anoxic conditions during the summer and fall (Burns and Ross, 1972), and thus the reason for the virtual extinction of *Cytherissa lacustris*.

The pattern, developed by plotting the maximum tolerable concentration of dissolved iron, for the ostracode faunal assemblage of each sample is given by figure 10. The range of soluble iron at or near the mud-water interface (Burns et al., 1976) is within the tolerance range of each species found in the samples. As previously pointed out, iron is released during the reduction of the surface sediments with a concomitant release of soluble reactive phosphorus in the decay of organic matter and the maintenance of high levels with anoxic conditions. The maximum tolerable level of phosphorus above or below 1.3 μmoles P/l for the faunal assemblages is given in figure 11. The boundary line of 1.3 μmoles P/l (0.12 mg PO_4/l) is that found by Burns and Ross (1972) to be "about average for anoxic hypolimnion water". Based on chemical data presented by Burns <u>et al</u>. (1976), concentrations of soluble reactive phosphorus in the bottom water of Lake Erie are within the range of the tolerance limits of the various species found in the lake.

Relative to benthic shelled invertebrates, stress caused by reducing dissolved oxygen concentrations can be calculated as follows: The square of the reciprocal of the difference between the minimum oxygen requirement for the survival of the faunal assemblage and the minimum oxygen requirement

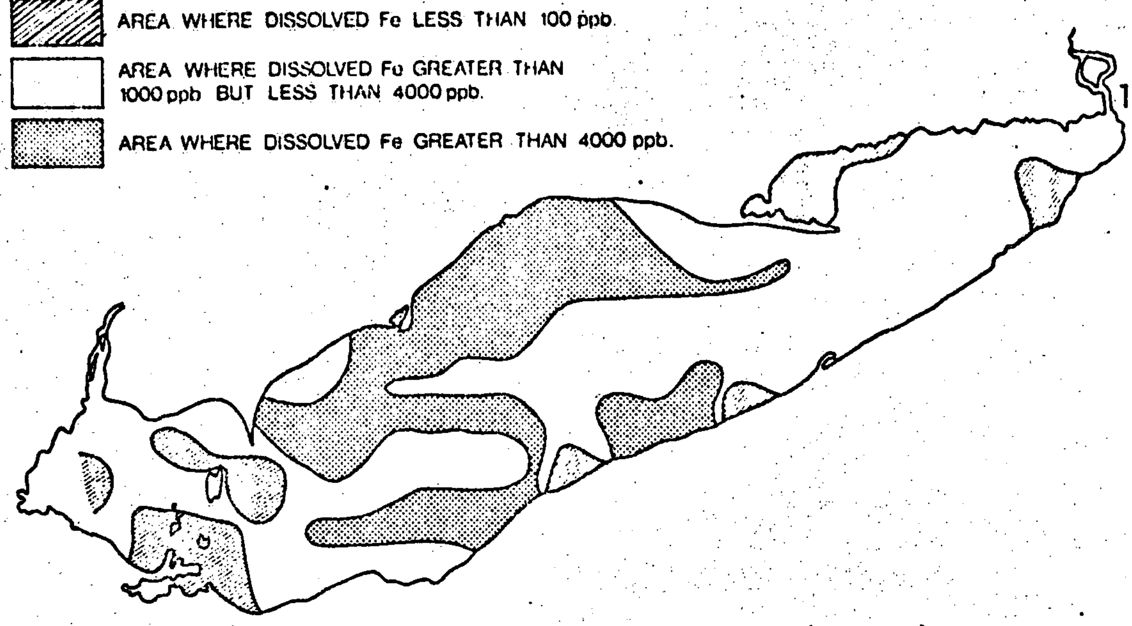

Figure 10. Maximum dissolved iron tolerated by the ostracode species recovered from the sediment-water interface of Lake Erie (1975).

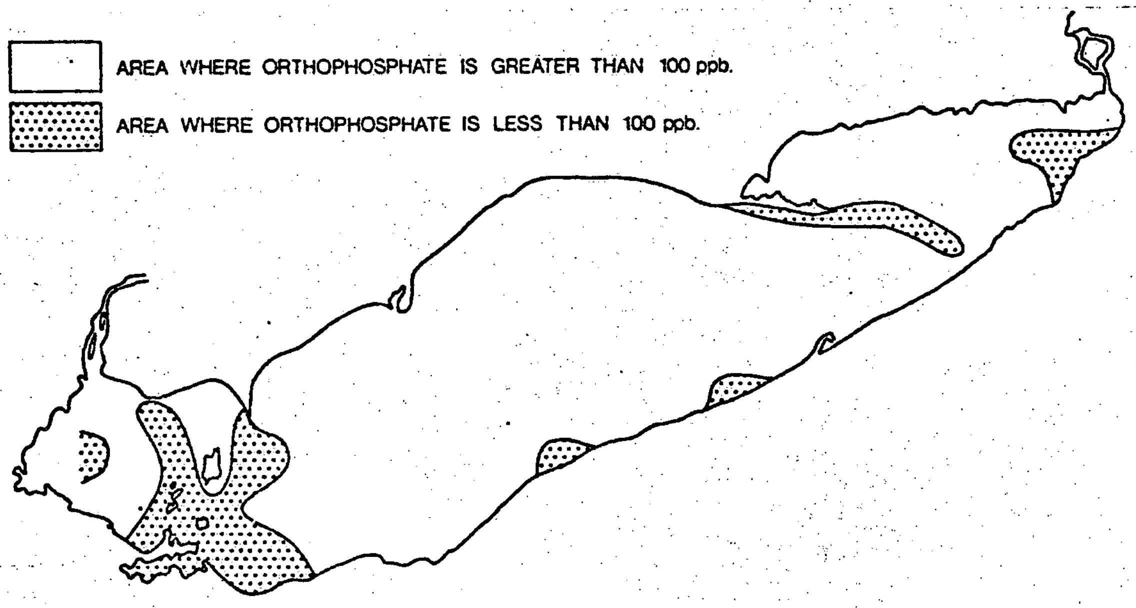

Figure 11. Maximum dissolved orthophosphate in which the ostracode species recovered from the sediment-water interface of Lake Erie (1975) could exist.

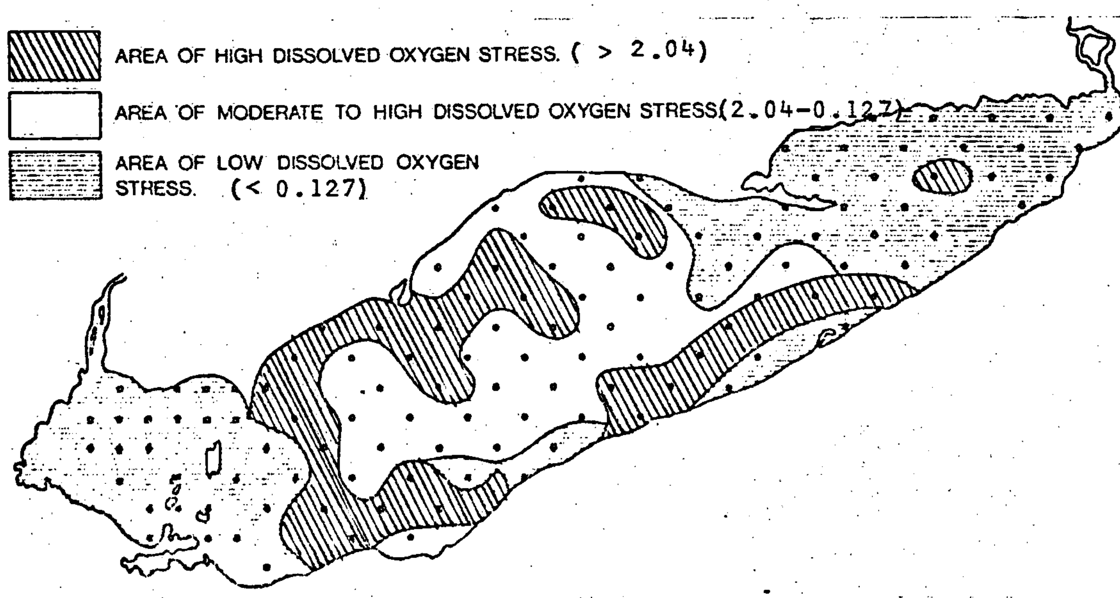

Figure 12. Dissolved oxygen stress for Lake Erie (1975).

for the survival of the last or most tolerant of the species of the faunal assemblage (see appendix III). Figure 12 is a plot of this difference (x), where $(1/x)^2$ is referred to as dissolved oxygen stress. Lake Erie can be subdivided into three subzones. The first area is that of very low stress located in the western and eastern basins. In the western basin, the difference ranged as high as 7.5 mg/l; while in the eastern basin, the value went as high as 8.3 mg/l. This means that the dissolved oxygen concentration could decrease by 7 or 8 mg/l before all, but one species, were killed off during their life cycles, which in most instances is one year. The primary difference between the western and eastern basins is one of species adaptation. In the western basin, colonization has been relegated to those species with short life cycles so that the species population can be maintained by many generations per year; a requirement brought about by the development of recurrent anoxic conditions and typical of shallow lakes and ponds where large temperature and oxygen fluctuations occur. In the eastern basin, colonization has been by species that tolerate more stable conditions, consequently these species are ones that have adapted to relatively high levels of oxygen. The more cosmopolitan species will tolerate lower oxygen levels. As long as this condition is stable, the oxygen stress will remain low. The next oxygen stress area, located in the central basin, is of moderate to high intensity. The difference ranges from 0.7 to 2.8 mg/l, DO stress of 2.04 to 0.127. This area is nearly surrounded by the highest stress area. The high stress area, of zero difference, is where permanent damage can be considered to have occurred. Inspection of figure 12 indicates that the moderate to high stress area is being encroached upon by the expansion of the high stress area. Indications are that benthic shelled invertebrates in the central basin have suffered permanent damage caused by low concentrations of dissolved oxygen during the immediate past.

Burns and Ross (1972, p. 104) state "the rate of oxygen depletion is clearly documented ... as being highest in the western end and along the south shoreline while the north shoreline, midlake, and the extreme eastern end of the basin had a lower rate of depletion." Examination of figures 9 and 12, of this study, clearly indicates that the problem of oxygen depletion along the south shoreline and the western end of the central basin has been in progress for some time, at least since 1930 (Dobson et al., 1972).

PALEOLIMNOLOGIC INTERPRETATIONS

In 1963, Benson and MacDonald discussed the distribution of fossil ostracodes from several cores collected in the eastern and central basins of Lake Erie. The discussion that follows will be based on the differences between the distribution of certain species of this study and those they recovered from the Holocene sediments. Their figure 5 shows two species, *Candona subtriangulata* and *Candona rawsoni* (their nomenclature *Candona nyensis*, see Delorme, 1970) as persisting to the surface sediments. *Candona subtriangulata* was not found in the central basin for this study (Fig. 8) and must therefore be considered to have become locally extinct, at least 45 years ago and probably longer, because of the development of anoxic conditions. The lowest acceptable limit of dissolved oxygen for *C. subtriangulata* is 5.6 mg/l. Apparently, *Candona rawsoni* met with the same fate, although this is not known for sure because it is not that common in the eastern basin. Benson and MacDonald (1963) comment that "this species was most abundant in the lowest part of the Lake Erie cores and appears to become extinct towards the tops of the cores". The cores they worked with did not penetrate the total thickness of the lacustrine sediments.

Candona caudata of this study incorporates the species of *C. caudata* and *C. novacaudata* of Benson and MacDonald (1963). There appears to be no change in the distribution of this species.

According to Benson and MacDonald (1963), "*Cytherissa lacustris* was found in most of the shallow water cores, but it was sparse in the deep-water [eastern basin], 35-foot core." From this study, the species had a good general distribution throughout both basins. Based on autecological studies of the two species, *C. lacustris* and *Candona subtriangulata*, (Tables 3, 4) there is no plausible chemical or physical reason why the two should not have co-habited the deeper part of the eastern basin during the Holocene.

The distribution of *Candona crogmaniana* given by Benson and MacDonald (1963) is for the bottom 15 feet of the 35-foot core from the deepest part of the eastern basin. In this study, the species was recovered from the sediments of both the eastern and central basins. Because of a lack of numerical data on their core, it would be difficult to explain this difference.

The virtual disappearance of *Limnocythere friabilis* from the central basin, as shown in this study, is at variance with the findings of Benson and MacDonald (1963), who state that it "was found at all core locations in Lake Erie but most prevalently in the shallow water cores and very sparsely in the deep water core ...". The north slope of the eastern basin is where the species was recovered from the sediment-water interface samples of this study, indicating its shallow water (down to 20 meters) preference.

CONCLUSIONS

1. The modern ostracode fauna is poorly represented in the sediment-water interface samples of this study. This may have been brought about by the removal of the swimming forms when the water was decanted off the Shipek dredge sample. However, this should not have removed the benthic forms which are commonly found below the euphotic zone. Renewed sampling for benthic organisms and the study of their chemical and physical habitat are in order.

2. The absence of live benthic forms, with life cycles of at least one year, was probably brought about by the development of anoxic conditions at the sediment-water interface, and the regeneration of dissolved iron, copper and orthophosphates, at the same interface, which could have become toxic to the organisms.

3. The distribution of ostracode species in the recent past is different from that elucidated by cores spanning the last several hundred years studied by others. Indications are that there have been dramatic changes in the chemical regime, such that many ostracode species have become locally extinct from the various basins and, generally, displaced to the eastern basin. More detailed studies of several cores from the three basins would be in order.

4. Changes in the bottom fauna have been brought about by chemical and physical changes in Lake Erie. This points out the need for analyses of chemical and physical data at the time of collection of the benthic fauna. This report would have been more pertinent to changes that have taken place

if these data had been collected on this and previous cruises. The study of bottom fauna for the sake of studying the distribution of the benthic forms is little more than useless. It does not allow one to determine the cause and effect relationships between organism and its habitat, and eventually the <u>food chain</u> and the aquatic environment "Lake Erie".

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APPENDIX I

OSTRACODE DISTRIBUTION BY
STATION NUMBER FOR
SAMPLES COLLECTED
IN 1975 FOR
LAKE ERIE

SYSTEMATICS

Phylum	ARTHROPODA
Class	CRUSTACEA
Subclass	OSTRACODA Latreille, 1806
Order	PODOCOPIDA Müller, 1894
Suborder	PODOCOPINA Sars, 1866
Superfamily	CYPRIDACEA Baird, 1845
Family	CYPRIDIDAE Bair, 1845
Subfamily	CYPRIDINAE Bair, 1845
Genus	ISOCYPRIS Müller, 1908
	Isocypris quadrisetosa, Rome, 1947
Subfamily	CYPRIDOPSINAE Kaufmann, 1900
Genus	CYPRIDOPSIS Brady, 1868
	Cypridopsis vidua (Müller), 1776
Family	CYCLOCYPIDIDAE Kaurmann, 1900
Genus	PHYSOCYPRIA Vavra, 1898
	Physocypria globula Furtos, 1933
	Physocypria inflata Furtos, 1933
	Physocypria pustulosa Sharpe, 1897
Genus	CYPRIA Zenker, 1854
	Cypria ophthalmica (Jurine), 1820

Family CANDONIDAE Kaufmann, 1900

Genus CANDONA Baird, 1845

Candona acuta Hoff, 1942

Candona candida (Müller), 1776

Candona caudata Kaufmann, 1900

Candona crogmaniana Turner, 1894

Candona elliptica Furtos, 1933

Candona eriensis Furtos, 1933

Candona faba Benson & Macdonald, 1963

Candona truncata Furtos, 1933

Candona intermedia Furtos, 1933

Candona rawsoni Tressler, 1957

Candona subtriangulata Benson & Macdonald, 1963

Family ILYOCYPRIDIDAE Kaufmann, 1900

Subfamily ILYOCYPRIDINAE Kaufmann, 1900

Genus ILYOCYPRIS Brady & Norman, 1889

Ilyocypris bradyi Sars, 1890

Superfamily DARWINULACEA Brady & Norman, 1889

Family DARWINULIDAE Brady & Norman, 1889

Genus DARWINULA Brady & Robertson <u>in</u> Jones, 1885

Darwinula stevensoni (Brady & Robertson), 1890

Superfamily CYTHERACEA Baird, 1850

Family CYTHERIDEIDAE Sars, 1928

Subfamily NEOCYTHEIRIDEIDINAE Puri, 1957

Genus CYTHERISSA Sars, 1928

Cytherissa lacustris (Sars), 1863

Family LIMNOCYTHERIDAE Klie, 1938

Genus LIMNOCYTHERE Brady, 1868

Limnocythere friabilis Benson & Macdonald, 1963

Limnocythere inopinata (Baird), 1843

Limnocythere ornata Furtos, 1933

Limnocythere pseudoreticulata Staplin, 1963

Limnocythere verrucosa Hoff, 1942

Limnocythere sp. A.

LAKE ERIE - WESTERN BASIN

A-9

Candona acuta 3*
Candona caudata 3
candona crogmaniana 3
Candona eriensis 3
Darwinula stevensoni 1

B-5

Candona acuta 3
Candona eriensis 3
Cypridopsis vidua 3
Darwinula stevensoni 3
Isocypris quadrisetosa 3
Limnocythere verrucosa 3
Physocypria inflata 3
Physocypria globula 1

B-7

Candona acuta 3
Candona eriensis 3
Darwinula stevensoni 3
Isocypris quadrisetosa 3
Limnocythere verrucosa 3
Physocypria inflata 3
Physocypris globula 1

B-8

Candona acuta 3
Candona caudata 3
Candona eriensis 3
Darwinula stevensoni 3
Physocypria globula 3

C-5

Candona caudata 3
Candona eriensis 3
Darwinula stevensoni 3
Physocypria inflata 3
Physocypria globula 3

* Indicates the state of life:
1. mature, live
2. immature, live
3. empty shells.

C-6

Candona acuta 3
Candona caudata 3
Candona eriensis 3
Darwinula stevensoni 3
Isocypris quadrisetosa 3
Physocypria inflata 3
Physocypria globula 1

C-7

Candona acuta 3
Candona caudata 3
Candona eriensis 3
Darwinula stevensoni 3
Isocypris quadrisetosa 3
Limnocythere verrucosa 3
Physocypria inflata 3
Physocypria globula 3

C-9

Candona sp. 3
Cytherissa lacustris 3
Isocypris quadrisetosa 3

D-4

Candona caudata 3
Physocypria globula 3

D-6

Candona acuta 3
Candona caudata 3
Candona eriensis 3
Candona sp. 3
Candona truncata 3
Candona elliptica 3
Cypridopsis vidua 3
Darwinula stevensoni 3
Candona intermedia 3
Isocypris quadrisetosa 3
Physocypria globula 3

D-7

Candona rawsoni 2
Limnocythere sp. A. 3

D-8

Candona acuta 3
Candona caudata 3
Candona eriensis 3
Candona sp. 3
Candona elliptica 3
Cypridopsis vidua 3
Cytherissa lacustris 3
Darwinsula stevensoni 3
Isocypris quadrisetosa 3
Limnocythere 3
Physocypria inflata 3
Physocypria globula 3

E-3

Candona caudata 3
Isocypris quadrisetosa 3
Physocypria inflata 3

E-4

Candona caudata 2
Darwinula stevensoni 3
Physocypris globula 3

E-5

Candona sp. 2

E-9

Candona acuta 3
Candona caudata 3
Candona eriensis 3
Candona rawsoni 3
Cytherissa lacustris 3
Isocypris quadrisetosa 3
Physocypria inflata 3
Physocypris globula 3
Physocypris pustulosa 3

F-3

Candona sp. 3

F-4

Candona caudata 3
Candona elliptica 3
Physocypria globula 3

F-5

Candona caudata 3
Isocypris quadrisetosa 3
Physocypria inflata 3
Physocypria globula 3

F-6

Candona caudata 2
Physocypria inflata 3

F-7

Candona acuta 2

F-8

Candona acuta 3
Candona caudata 3
Candona eriensis 3
Isocypris quadrisetosa 3
Limnocythere sp. A. 3

G-4

Candona sp. 3

G-6

Candona rawsoni
Cypridopsis vidua

G-7

Candona caudata 3
Candona sp. 3
Candona rawsoni 3
Darwinula stevensoni 3

G-8

Candona sp. 3

LAKE ERIE - CENTRAL BASIN

B-12

Candona caudata 3
Candona crogmaniana 3

B-14

Candona caudata 3
Candona crogmaniana 3
Cytherissa lacustris 3

C-11

Candona caudata 2

C-13

Candona caudata 2

C-15

Candona caudata 3

C-17

Nil

D-10

Candona acuta 3
Candona caudata 3
Candona intermedia 3
Cytherissa lacustris 3
Limnocythere sp. A. 3

D-12

Candona crogmaniana 3
Cytherissa lacustris 3

D-14

Candona caudata 2

D-16

Candona caudata 3
Cytherissa lacustris 3

D-18

Candona caudata 2
Cypridopsis vidua 3

E-11

Candona caudata 1

E-13

Candona caudata 2
Candona crogmaniana 3
Cytherissa lacustris 3

E-15

Candona caudata 3
Candona crogmaniana 3
Candona rawsoni 3
Cytherissa lacustris

E-17

Candona caudata 3
Candona crogmaniana 3
Cytherissa lacustris 3

E-19

Candona caudata 3
Cypridopsis vidua 3
Isocypris quadrisetosa 3
Physocypria inflata 3
Physocypria globula 3

F-10

Cytherissa lacustris 3

F-12

Candona caudata 1
Cytherissa lacustris 3

F-14

Candona acuta 3
Candona crogmaniana 3
Cytherissa lacustris 3

F-16

Candona caudata 1
Candona crogmaniana 3
Candona faba 3
Cytherissa lacustris 3

F-18

Candona caudata 3
Cytherissa lacustris 3

F-20

Candona caudata 3
Candona crogmaniana 3
Cytherissa lacustris 3

F-22

Candona caudata 3

G-9

Candona caudata 3

G-13

Candona caudata 1
Cytherissa lacustris 3

G-15

Candona caudata 2

G-17

Candona caudata 2
Cytherissa lacustris 3

G-19

Candona caudata 1
Candona crogmaniana 3
Cytherissa lacustris 3

G-21

Candona caudata 2

G-23

Candona caudata 3

G-25

Candona caudata 3
Cypridopsis vidua 3
Isocypris quadrisetosa 3
Physocypria inflata 3
Physocypria globula 3
Cytherissa lacustris 3

H-10

Nil

H-12

Candona caudata 3
Cytherissa lacustris 3

H-14

Candona sp. 3

H-16

Candona caudata 3
Candona crogmaniana 3
Candona faba 3
Cytherissa lacustris 3

H-18

Candona caudata 3
Candona crogmaniana 3
Cytherissa lacustris 3

H-20

Candona caudata 3
Candona intermedia 3

H-22

Candona candida 3
Candona caudata 3
Candona intermedia 3
Physocypria sp. 3

H-24

Candona caudata 3

H-26

Candona caudata 3
Candona candida 3

I-11

Candona caudata 3
Candona crogmaniana 3

I-13

Candona sp. 3
Cytherissa lacustris 3

I-15

Candona caudata 3

I-17

Candona caudata 2
Cytherissa lacustris 3

I-19

Candona intermedia 3

I-21

Candona caudata 3
Candona crogmaniana 3
Cytherissa lacustris 3

I-25

Cytherissa lacustris 3

J-16

Candona sp. 2

J-18

Candona sp. 2
Cytherissa lacustris 2

J-20

Candona eriensis 2
Cytherissa lacustris 3

J-22

Candona caudata 3
Candona crogmaniana 3
Cytherissa lacustris 3

J-24

Candona caudata 3
Candona rawsoni 3
Cytherissa lacustris 3
Isocypris quadrisetosa 3
Physocypria globula 3

J-26

Candona crogmaniana 3
Cytherissa lacustris 3
Physocypria sp. 3

K-15

Candona caudata 3
Cytherissa lacustris 3

K-17

Cytherissa lacustris 3

K-19

Candona caudata 1
Cytherissa lacustris 3

K-21

Candona caudata 2
Cytherissa lacustris 3
Candona candida 3

K-23

Candona caudata 1
Cytherissa lacustris 3

L-18

Candona caudata 3
Cytherissa lacustris 3

L-20

Candona caudata 2
Cytherissa lacustris 1

L-22

Candona caudata 1

L-24

Candona caudata 1
Candona crogmaniana 3
Candona rawsoni 3
Isocypris quadrisetosa 3
Limnocythere friabilis 3
Limnocythere verrucosa 3
Limnocythere sp. A. 3
Physocypria globula 3

L-26

Candona candida 3
Candona caudata 3
Candona rawsoni 3
Cytherissa lacustris 3

M-17

Candona caudata 3
Cytherissa lacustris 3

M-19

Candona caudata 1

M-21

Candona caudata 1

M-23

Candona caudata 3
Cytherissa lacustris 3
Isocypris quadrisetosa 3
Limnocythere friabilis 3
Limnocythere verrucosa 3
Physocypris globula 3

M-25

Candona caudata 3
Cytherissa lacustris 3
Isocypris quadrisetosa 3
Limnocythere friabilis 3
Limnocythere sp. A. 3
Physocypria globula 3

N-20

Candona caudata 3
Cytherissa lacustris 3

N-22

Candona caudata 3
Cytherissa lacustris 3
Isocypris quadrisetosa 3
Physocypria sp. 2

LAKE ERIE - EASTERN BASIN

I-27

Candona sp. 3
Candona rawsoni 3

I-29

Candona caudata 3
Cypridopsis vidua 3
Isocypris quadrisetosa 3
Physocypria globula 3

J-28

Candona sp. 3

J-30

Candona sp. 2
Physocypria globula 1

K-29

Candona caudata 1
Candona crogmaniana 1
Candona rawsoni 3
Candona subtriangulata 3
Cytherissa lacustris 1
Limnocythere friabilis 1

K-31

Candona caudata *3
Candona crogmaniana 3
Candona faba 1
Candona subtriangulata 3
Cytherissa lacustris 3

L-28

Candona caudata *3
Candona crogmaniana 3
Candona faba 3
Candona rawsoni 3
Candona subtriangulata 3
Cytherissa lacustris 3
Physocypria globula 3

L-30

Candona candida 3
Candona caudata *3
Candona crogmaniana 3
Candona faba 3
Candona rawsoni 3
Candona subtriangulata 3
Cytherissa lacustris 3

L-32

Candona candida 3
Candona caudata *1
Candona crogmaniana 3
Candona faba 1
Candona eriensis 3
Candona subtriangulata 3
Cytherissa lacustris 3

M-27

Candona caudata 2
Candona eriensis 3
Candona rawsoni 3
Isocypris quadrisetosa 2
Limnocythere sp. A. 3

M-29

Candona caudata 3
Candona candida 3
Candona crogmaniana 3
Candona eriensis 3
Candona faba 3
Candona subtriangulata 3
Cytherissa lacustris 3

M-31

Candona candida 3
Candona caudata *3
Candona crogmaniana 1
Candona eriensis 3
Candona subtriangulata 3
Cytherissa lacustris 3

---

* dwarfed forms

M-35

Candona caudata 3
Isocypris quadrisetosa 3

N-28

Candona caudata 1
Candona rawsoni 3
Candona subtriangulata 3
Cytherissa lacustris 1
Isocypris quadrisetosa 1
Ilyocypris bradyi 1
Limnocythere friabilis 1
Limnocythere pseudoreticulata 3
Limnocythere sp. A. 3
Physocypria globula 1

N-30

Candona caudata *†3
Candona crogmaniana 1
Candona faba 1
Candona rawsoni 3
Candona subtriangulata 3
Cytherissa lacustris 3

N-32

Candona caudata *3
Candona crogmaniana 3
Candona faba 3

N-34

Candona candida 3
Candona caudata *†3
Candona crogmaniana *3
Candona faba 3
Candona rawsoni 3
Candona subtriangulata *3
Cytherissa lacustris 3
Isocypris quadrisetosa 3
Limnocythere friabilis 3
Physocypria globula 3

N-36

Candona caudata 3
Candona crogmaniana 3
Candona rawsoni 3
Cypridopsis vidua 3
Icosypris quadrisetosa 3
Physocypria inflata 3
Physocypris globula 3

O-27

Candona caudata 1
Cytherissa lacustris 3
Isocypris quadrisetosa 2
Ilyocypris bradyi 1
Limnocythere friabilis 3
Limnocythere inopinata 3
Limnocythere ornata 3
Limnocythere pseudoreticulata 3
Limnocythere verrucosa 3
Limnocythere sp. A.
Physocypris globula 1

O-29

Candona caudata 1
Candona subtriangulata 3
Cytherissa lacustris 3
Isocypris quadrisetosa 2
Limnocythere friabilis 3
Phycocypria globula 1

O-31

Candona caudata *†3
Candona crogmaniana 3
Candona faba 3
Candona rawsoni 3
Candona subtriangulata 3
Cytherissa lacustris 3
Cypria ophtalmica 3

---

* dwarfed forms
† normal size forms

O-33

Candona caudata *†3
Candona crogmaniana 3
Candona rawsoni 3
Candona subtriangulata 3
Cytherissa lacustris 3
Limnocythere friabilis 3
Physocypris globula 3

O-35

Candona caudata *† 3
Cytherissa lacustris 3
Limnocythere sp. A. 3
Physocypria inflata 3

O-37

Candona caudata 3
Cypridopsis vidua 3
Isocypris quadrisetosa 3
Physocypria globula 1
Physocypria inflata 1

P-30

Candona caudata 2
Candona subtriangulata 3
Cypridopsis vidua 3
Cytherissa lacustris 3
Isocypris quadrisetosa 2
Limnocythere friabilis 3
Limnocythere pseudoreticulata 3
Limnocythere verrucosa 3
Limnocythere sp. A. 3
Physocypria globula 1

P-32

Candona caudata 3
Candona faba 3
Candona rawsoni 3
Candona subtriangulata 3
Cytherissa lacustris 3
Isocypris quadrisetosa 3
Limnocythere sp. A. 3
Physocypris globula 3

P-34

Candona caudata 2
Candona rawsoni 3
Cypridopsis vidua 3
Cytherissa lacustris 3
Limnocythere friabilis 3
Limnocythere verrucosa 3

P-36

Candona caudata 3
Candona crogmaniana 3
Candona faba 3
Candona rawsoni 3
Candona subtriangulata 3
Cypridopsis vidua 3
Cytherissa lacustris 3
Limnocythere friabilis 3
Limnocythere verrucosa 3
Limnocythere sp. A. 3
Physocypria globula 3

P-38

Cytherissa lacustris 3
Isocypris quadrisetosa 1
Physocypria globula 1

---

* dwarfed forms
† normal size forms

APPENDIX II

GEOGRAPHIC COORDINATES OF

LAKE ERIE

(1975)

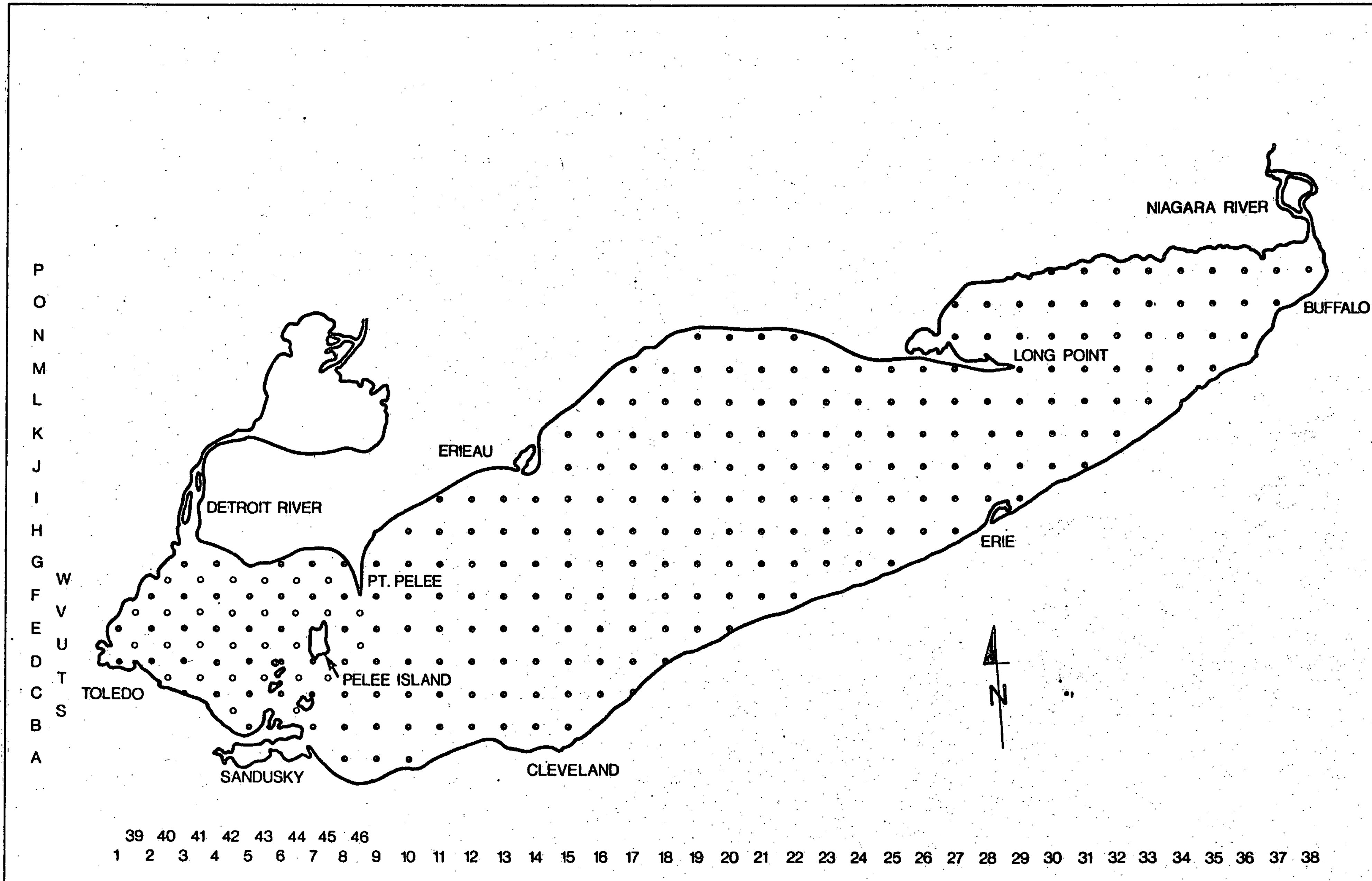
SURVEY STATIONS

Station Number	Latitude N.	Longitude W.
A- 9	41° 27' 16"	82° 26' 12"
B- 5	41° 32' 15"	82° 55' 05"
B- 7	41° 32' 29"	82° 40' 42"
B- 8	41° 32' 35"	82° 33' 31'
B-10	41° 32' 42"	82° 19' 08"
B-12	41° 32' 55"	82° 04' 45"
B-14	41° 33' 02"	81° 50' 22"
C- 4	41° 37' 32"	83° 02' 26"
C- 5	41° 37' 40"	82° 55' 14"
C- 6	41° 37' 46"	82° 48' 02"
C- 7	41° 37' 53"	82° 40' 56"
C- 9	41° 38' 05"	82° 26' 26"
C-11	41° 38' 14"	82° 12' 02"
C-13	41° 38' 23"	81° 57' 38"
C-15	41° 38' 29"	81° 43' 14"
C-17	41° 38' 46"	81° 28' 49"
D- 1	41° 42' 31"	83° 24' 14"
D- 2	41° 42' 40"	83° 17' 01"
D- 3	41° 42' 48"	83° 09' 49"
D- 4	41° 42' 56"	83° 02' 37"
D- 5	41° 43' 04"	82° 55' 24"
D- 6	41° 43' 11"	82° 48' 11"
D- 7	41° 43' 17"	82° 40' 59"
D- 8	41° 43' 24"	82° 33' 46"
D-10	41° 43' 34"	82° 19' 21"
D-12	41° 43' 43"	82° 04' 56"
D-14	41° 43' 50"	81° 50' 30"
D-16	41° 43' 56"	81° 36' 04"
D-18	41° 43' 59"	81° 21' 38"
E- 1	41° 47' 55"	83° 24' 26"
E- 2	41° 48' 04"	83° 17' 13"
E- 3	41° 48' 12"	83° 10' 00"
E- 4	41° 48' 20"	83° 02' 47"
E- 5	41° 48' 28"	82° 55' 34"
E- 6	41° 48' 35"	82° 48' 21"

Station Number	Latitude N.	Longitude W.
E- 9	41° 48 53"	82° 26' 41"
E-11	41° 49' 03"	82° 12' 14"
E-13	41° 49' 11"	81° 57' 48"
E-15	41° 49' 17"	81° 43' 21"
E-17	41° 49' 22"	81° 28' 54"
E-19	41° 49' 25"	81° 14' 27"
F- 2	41° 53' 28"	83° 17' 25"
F- 3	41° 53' 36"	83° 10' 11"
F- 4	41° 53' 44"	83° 02' 58"
F- 5	41° 53' 51"	82° 55' 44"
F- 6	41° 53' 59"	82° 48' 30"
F- 7	41° 54' 05"	82° 41' 16"
F- 8	41° 54' 11"	82° 34' 02"
F-10	41° 54' 22"	82° 19' 34"
F-12	41° 54' 31"	82° 05' 06"
F-14	41° 54' 39"	81° 50' 38"
F-16	41° 54' 44"	81° 36' 10"
F-18	41° 54' 48"	81° 21' 42"
F-20	41° 54' 50"	81° 07' 14"
F-22	41° 54' 50"	80° 52' 46"
G- 3	41° 59' 00"	83° 10' 22"
G- 4	41° 59' 08"	83° 03' 07"
G- 6	41° 59' 23"	82° 48' 39"
G- 7	41° 59' 29"	82° 41' 25"
G- 8	41° 59' 35"	82° 34' 10"
G- 9	41° 59' 41"	82° 26' 56"
G-11	41° 59' 52"	82° 12' 26"
G-13	41° 59' 59"	81° 57' 58"
G-15	42° 00' 06"	81° 43' 28"
G-16	42° 00' 08"	81° 36' 13"
G-17	42° 00' 11"	81° 28' 59"
G-19	42° 00' 13"	81° 14' 29"
G-21	42° 00' 14"	81° 00' 00"
G-23	42° 00' 13"	80° 45' 30"
G-25	42° 00' 11"	80° 31' 01"
H-10	42° 05' 11"	82° 19' 48"
H-12	42° 05' 20"	82° 05' 17"
H-14	42° 05' 27"	81° 50' 47"
H-16	42° 05' 33"	81° 36' 17"
H-18	42° 05' 37"	81° 21' 46"

Station Number	Latitude N.	Longitude W.
H-20	42° 05' 38"	81° 07' 16"
H-22	42° 05' 38"	80° 52' 44"
H-24	42° 05' 37"	80° 38' 14"
H-26	42° 05' 33"	80° 23' 43"
I-11	42° 10' 40"	82° 12' 39"
I-13	42° 10' 48"	81° 58' 07"
I-15	42° 10' 55"	81° 43' 35"
I-17	42° 10' 59"	81° 29' 04"
I-19	42° 11' 02"	81° 14' 32"
I-21	42° 11' 02"	81° 00' 00"
I-23	42° 11' 02"	80° 45' 28"
I-25	42° 10' 59"	80° 30' 56"
I-27	42° 10' 55"	80° 16' 25"
I-29	42° 10' 48"	80° 01' 53"
J-16	42° 16' 21"	81° 36' 23"
J-18	42° 16' 25"	81° 21' 50"
J-20	42° 16' 26"	81° 07' 17"
J-22	42° 16' 26"	80° 52' 43"
J-24	42° 16' 25"	80° 38' 11"
J-26	42° 16' 21"	80° 23' 37"
J-28	42° 16' 16"	80° 09' 04"
J-30	42° 16' 08"	79° 54' 31"
K-15	42° 21' 43"	81° 43' 43"
K-17	42° 21' 47"	81° 29' 08"
K-19	42° 21' 50"	81° 14' 34"
K-21	42° 21' 51"	81° 00' 00"
K-23	42° 21' 50"	80° 45' 26"
K-25	42° 21' 47"	80° 30' 52"
K-27	42° 21' 43"	80° 16' 17"
K-29	42° 21' 36"	80° 01' 43"
K-31	42° 21' 28"	79° 47' 08"
L-16	42° 27' 10"	81° 36' 29"
L-18	42° 27' 13"	81° 21' 53"
L-20	42° 27' 15"	81° 07' 18"
L-22	42° 27' 15"	80° 52' 42"
L-24	42° 27' 13"	80° 38' 06"
L-26	42° 27' 10"	80° 23' 31"
L-28	42° 27' 04"	80° 08' 56"
L-30	42° 26' 56"	79° 54' 20"
L-32	42° 26' 47"	79° 39' 45"

Station Number	Latitude N.	Longitude W.
M-17	42° 32' 38"	81° 29' 14"
M-19	42° 32' 38"	81° 14' 37"
M-21	42° 32' 40"	81° 00' 00"
M-23	42° 32' 38"	80° 45' 23"
M-25	42° 32' 36"	80° 30' 46"
M-27	42° 32' 31"	80° 16' 10"
M-29	42° 32' 25"	80° 01' 33"
M-31	42° 32' 16"	79° 46' 56"
M-32	42° 32' 11"	79° 39' 38"
M-33	42° 32' 06"	79° 32' 20"
M-35	42° 31' 54"	79° 17' 43"
N-20	42° 38' 04"	81° 07' 19"
N-22	42° 38' 04"	80° 52' 41"
N-28	42° 37' 52"	80° 08' 47"
N-30	42° 37' 45"	79° 54' 09"
N-32	42° 37' 35"	79° 39' 31"
N-34	42° 37' 24"	79° 24' 53"
N-36	42° 37' 11"	79° 10' 16"
0-27	42° 43' 19"	80° 16' 02"
0-29	42° 43' 13"	80° 01' 23"
0-31	42° 43' 05"	79° 46' 44"
0-33	42° 42' 55"	79° 32' 04"
0-35	42° 42' 42"	79° 17' 25"
0-37	42° 42' 28"	79° 02' 47"
P-30	42° 48' 33"	79° 53' 58"
P-32	42° 48' 24"	79° 39' 17"
P-34	42° 48' 13"	79° 34' 37"
P-36	42° 47' 59"	79° 09' 56"
P-38	42° 47' 44"	78° 55' 17"
U-42	41° 45' 40"	82° 59' 06"
V-43	41° 51' 11"	82° 52' 02"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BUFFALO
LONG POINT
ERIEAU
ERIE
DETROIT RIVER
PT. PELEE
PELEE ISLAND
TOLEDO
SANDUSKY
CLEVELAND
N
P O N M L K J I H G F E D C B A
W V U T S
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APPENDIX III

CALCULATION OF THE MINIMUM TOLERABLE DISSOLVED OXYGEN LEVEL ACCEPTABLE FOR THE OSTRACODE FAUNAL ASSEMBLAGE AT STATION 1-21 AND THE DISSOLVED OXYGEN STRESS AT STATION 1-21

	Minimum DO level*
Candona caudata	2.3 mg/l
Candona crogmaniana	2.3 mg/l
Cytherissa lacustris	3.0 mg/l

The required value (3.0 mg/l) is then the highest of these minimum values which will sustain all of these species at the same locality.

Dissolved Oxygen Stress

The DO stress value is the difference between minimum DO value required to maintain the assemblage (in this case 3 mg/l) and the minimum value required to maintain the last species (in this case 2.3 mg/l for either C. *caudata* or C. *crogmaniana*). Therefore, the difference is 3 - 2.3 = .7 mg/l, and the DO stress is $(1/.7)^2 = 2.04$.

* From table 2.