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December 1977

UNPUBLISHED REPORT
RAPPORT NON PUBLIE

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* Submitted to Journal of Great Lakes Research
December 6, 1977.

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ABSTRACT

Sediment samples collected from the sediment-water interface from Lake Erie in 1975 indicate the presence of 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.

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 6720 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, 2000 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.

DISTRIBUTION OF THREE IMPORTANT OSTRACODE SPECIES

Candona caudata. The distribution of shells of *Candona caudata* (Fig. 1) appears to be uniform. The dispersal of live specimens, however, is restricted to the middle part of the central basin and the north shore of the eastern basin.

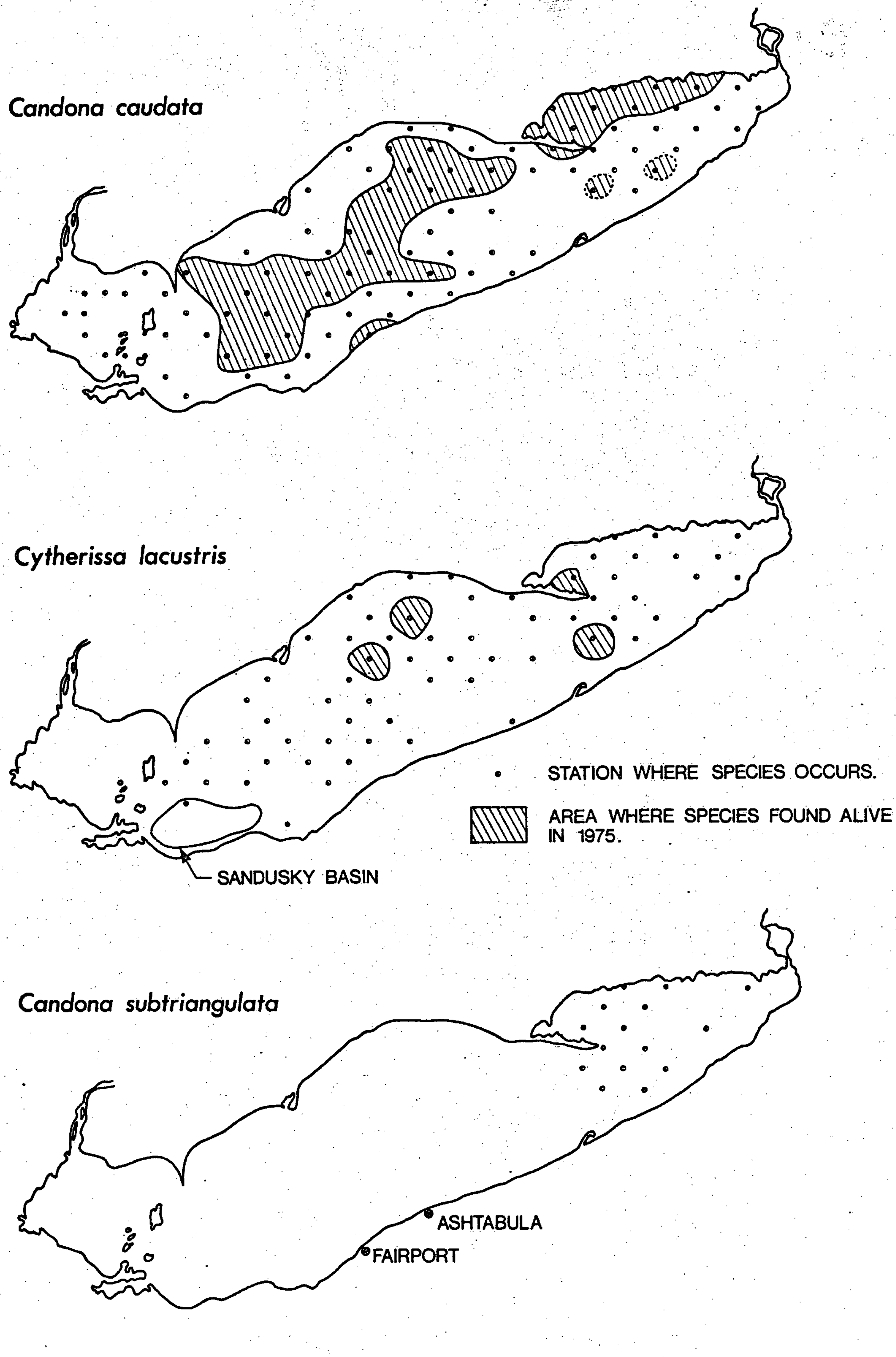

FIGURE 1. DISTRIBUTION OF THREE OSTRACODE SPECIES IN LAKE ERIE.

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.

Burns and Ross (1972) have indicated that anoxic conditions have been prevalent in the late summer and fall in the central basin. Table 2 indicates that the lowest value of dissolved oxygen tolerated by C. *caudata* is 2.3 mg/l,

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.

and on this basis it seems that the species should not be living in the central basin. However, table 1 shows that the life cycle for this species is fairly short, thereby allowing it to become locally extinct for a short period of time. Unhatched eggs that remain can survive anoxia and propagate the species at some later time when anoxic conditions have disappeared.

Cytherissa lacustris. Table 1 shows a high percentage of *Cytherissa lacustris* occurring in the central and eastern basins. *Cytherissa lacustris* is a benthic form and live specimens were not lost with water decanted from the Shipek sample, however, figure 1 illustrates that the species was not found living in these basins except for four small localities. It is clear from table 3 that depth has not limited the species in Lake Erie. The lower

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	16.8 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.

limit of dissolved oxygen required by C. *lacustris* is 3 mg/l. As was pointed out by Burns and Ross (1972), lower levels of dissolved oxygen than this have been attained over most of the central basin. *Cytherissa lacustris* differs from *Candona caudata* because it has a life cycle which approaches or goes beyond one year in duration. Consequently, the species can become locally extinct if the adults are killed off by the development of anoxic conditions. Unhatched eggs will develop later when the area is reoxygenated, but the nauplii will be killed off the following year if anoxic conditions develop every summer in that area. An excellent example of this is the Sandusky Basin which is known to go anoxic each year (Burns, 1977, personal communication) and which does not even show the presence of empty shells in the 1975 survey (Fig. 1). However, the rest of the central basin does not go anoxic every year (Herdendorf, C.E., 1977. CLEAR Technical Report no. 59) and *Cytherissa lacustris* has existed in these parts recently. From analyses of cores from the central and eastern basins, Benson and MacDonald (1963) have shown that *Cytherissa lacustris* has been a common constituent of these basins for many hundred of years prior to the development of periodic oxygenless conditions.

Candona subtriangulata. Fossil shells of *Candona subtriangulata* are restricted to the eastern basin (Fig. 3). Depth could not have restricted the species to the eastern basin, because autecological data (Table 4) indicate that C. *subtriangulata* has a depth range of 7.6 to 273 meters. If depth were the single controlling factor, this species would then have existed 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). More restrictive than depth, however, is the minimum

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.

requirement of 5.6 mg/l dissolved oxygen for the species. Clearly, oxygen values of lower than 5.6 mg/l have been frequently attained for 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 even yet occurred on a basin-wide basis.

In 1963, Benson and MacDonald studied the fossil ostracodes of several cores collected in 1961 from the central and eastern basins of Lake Erie. They found that in the eastern basin, *Candona subtriangulata* had been present for a long period of time (probably several hundred years). Although they studied four cores from the central basin, they only reported on two from along the south shore. One short core, north-west of Ashtabula, did not contain C. *subtriangulata*. In the other core, north of Fairport Harbor, the species was present in the lower half; unfortunately the top half of the core was either lost or not analyzed. Regardless of the shells recovered from these two cores, indications are that the species did exist in at least part of the central basin during its history. This would indicate that some major chemical and/or physical changes occurred in the central basin during the last hundred years causing the species to become extinct a long time ago. Analyses of further cores for the central basin taken from all over the lake would help determine when these changes took place, as well as attempt to identify the changes that took place.

CONCLUSIONS

Changes in the ostracode bottom fauna have been brought about by chemical and/or physical changes in Lake Erie during the life cycle of the individual species. Repetition of these chemical and/or physical changes have brought about a permanent change in the ostracode fauna. It is not possible to determine the chemical and/or physical changes which have brought about the changes in the fauna. This is because chemical and physical data of the aquatic habitat were not collected at the time benthic fauna was collected. These data are important because of the following analyses which can be carried out:

1. Determine whether or not the parameter in question (e.g. dissolved oxygen) is within the minimum-maximum range for the species. If specimens of the species are alive and the parameter is within the range, then the parameter in this situation is not limiting. If species are fossil (empty shells) and the parameter is outside the range, then the parameter was limiting; if the parameter was within the range, then some other parameter(s) was limiting.
2. If the specimens of the species are found alive but the parameter (e.g. dissolved oxygen) is found outside the known range for the species, then the value of the parameter should be considered to be a new piece of information which extends the range of the parameter for the species.

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, before the study of the ecology (the relationship between the species and the Lake Erie habitat), is little more than useless. It does not allow one to determine the cause and effect relationships between organisms and its habitat, and eventually the food chain and the aquatic environment "Lake Erie".

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