CHANGES IN THE ALGAL FLORA OF EAST HARBOR, OTTAWA COUNTY, OHIO, SINCE 1900[1]

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ABSTRACT

FREDERICK, V. RAY. Changes in the Algal Flora of East Harbor, Ottawa County, Ohio since 1900. Ohio J. Sci. 75(5): 229, 1975.

Algal collections from East Harbor in 1974 were compared with those taken prior to that year. Of the 265 algal taxa reported from East Harbor from 1900 to 1974, only 18% are common to the 1974 study and to all previous studies. Only 31% of the 151 taxa identified before 1974 are present at East Harbor. These differences may be attributed to natural and man-induced disturbances. However, the major impact would stem from man-induced disturbances in general and the 1967 dredging of the harbor in particular. This deepened the harbor, destroyed most of the submersed vegetation, and altered the water chemistry. The changes in the algal flora are significant and may reflect man's effect on the aquatic environment.

The aquatic vegetation of the western end of Lake Erie has been investigated since the late nineteenth century. The existance of early collection data makes it possible to study changes in the aquatic flora over the past eighty years. When the results of these studies are completed, a relative indication of man's influence on the aquatic environment, particularly in Lake Erie, can be demonstrated.

In 1945, East Harbor State Park became the first state-owned park on Lake Erie. The park is located 72 kilometers east of Toledo and 130 kilometers west of Cleveland, at the junction of State Routes 163 and 269, near Sandusky, Ohio. The park encompasses 653 hetares including 277 hectares in East Harbor. The harbor is nearly landlocked, with only a narrow channel connecting it to Lake Erie (fig. 1). Dredging operations commenced in 1946 and continued as small localized operations until 1967 when major dredging was initiated. Prior to 1967, the harbor was generally less than two meters deep and submersed vegetation grew to the surface. Channels had to be opened to allow fishermen access to parts of the harbor. The 1967 dredging deepened the harbor, and most of the submersed vegetation the harbor once contained was destroyed. A more complete history of East Harbor is provided by Moore (1973).

The vascular aquatic flora of East harbor has been studied by a number of authors from Moseley (1899) to Moore (1973). Moore consolidated previous studies of East Harbor with his study into an extensive history of the harbor and its vascular flora. He found a great many changes had occurred in the vascular flora since the study by Moseley, which he attributed to

> ". . . such natural disturbances as wind and water erosion, fluctuating water levels, invasion, establishment, and spread of species new to the park, or rampant expansion of species already present." In addition, the changes may ". . . have also been effected by man-induced disturbances such as dredging the harbor, fish control, revegetation attempts, clearing and filling sections of the beach area, power boats, . . . and erosion of trails and heavily trafficked areas."

Early studies of the algae of East Harbor date back to Jennings (1900). Numerous authors have collected in the harbor area since that time but no extensive collections have been made since the early 1940's when C. E. Taft (1942) with his students from the Franz Theodore Stone Laboratory, collected the area. My study compares the algal flora of East Harbor in 1974 to that prior to the mid-1940's and attempts to show that past and present algal flora data may

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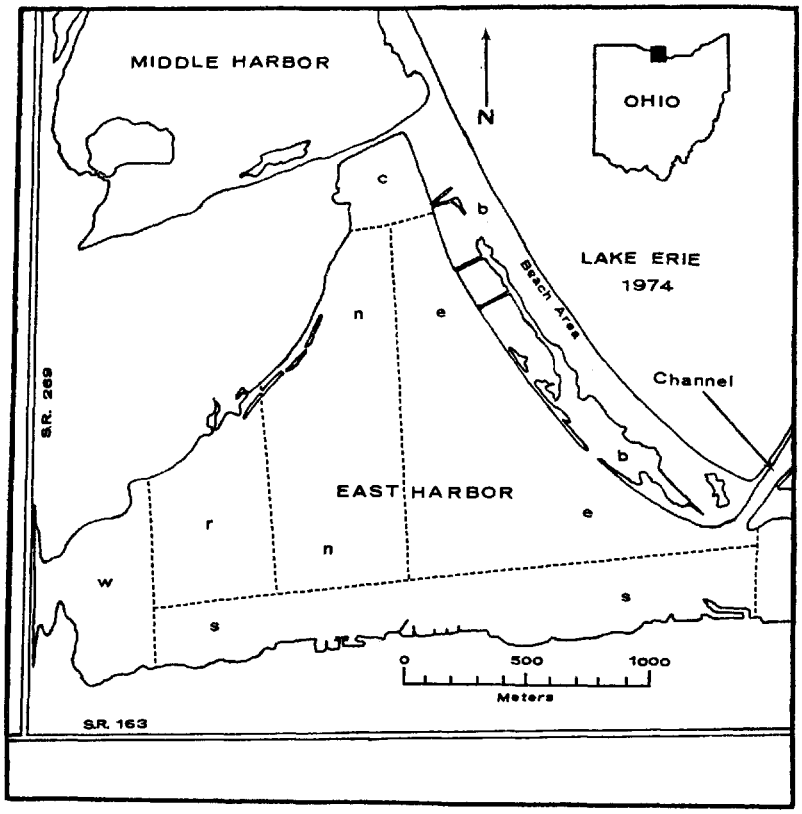

FIGURE 1. Map of East Harbor reflecting high water levels encountered during the 1974 study period with collection sites indicated by letters. (Modified from Moore, 1973).

provide some insight into the effect of man on the aquatic environment.

METHODS

Algae were collected weekly from East Harbor from mid-June through mid-August, 1974. Methods, sites, and season of collection were identical to those of earlier authors (Taft, 1975, personal communication). Net samples were taken with a number 25 standard, silk bolting cloth net (83 meshes per centimeter). Euplankton, tychoplankton, benthic, and grab samples were returned to the Franz Theodore Stone Laboratory and preserved in Transeau's fixative (6 parts water, 3 parts 95% ethanol, 1 part formalin). Wet mounts of the specimens were examined with a microscope, using magnifications up to 1200 diameters and voucher specimens were deposited at The Ohio State University, Department of Botany.

Water at East Harbor was analysed chemically at three locations on each of two occasions. A Hach Model AL-36B, portable test kit was used to determine total acidity, total alkalinity, total hardness, carbon dioxide, dissolved oxygen, and pH (table 1). Nitrate and nitrite nitrogen in addition to ortho- and metaphosphate concentrations were determined using a Hach Model DR-EL, Direct Reading Engineer's Laboratory (table 1). Water tem-

TABLE 1
East Harbor water chemistry, pH, and temperature.

	6/30/74	7/28/74
Total acidity*	10	5
Total alkalinity*	137	154
Total hardness*	137	137
CO_2*	10	5
Dissolved oxygen*	7	9
Nitrate nitrogen*		0.12
Nitrite nitrogen*		0.0083
Orthophosphate*		0.033
Metaphosphate*		0.034
pH	9.4	9.1
Water temperature °C	21	24

*Expressed in mg/*l*.

peratures were also recorded. The system of classification used in this study is that of Prescott (1968).

RESULTS AND DISCUSSION

The algae identified during this study were compared with algae previously reported from East Harbor. The list of East Harbor algae presented in Taft and Taft (1971)—to which the present algal list is compared—was compiled from three major sources, Pieters (1902), Tiffany (1934, 1937), and Taft (1945) and several other sources (table 2) and covers the studies before 1971. Only four additional algal taxa were reported from East Harbor after 1945, and prior to this study (Taft, 1964; Taft and Taft, 1971).

TABLE 2

Algae reported from East Harbor by Frederick (1974) and in all previous studies as compiled in Taft and Taft (1971).

Taxa	1974**	1971 and earlier*
Chlorophyta		
Actinastrum hantzschii Lagerheim	Pb	—
Ankistrodesmus falcatus (Corda) Ralfs	TcBc	3
A. falcatus var. *spirilliformis* G.S. West	Pb	3***
Aphanochaete repens A. Braun	Pr	—
Apiocystis branuiana Naegeli	E	3
Botryococcus braunii Kuetzing	E	8***
Bulbochaete crenulata Pringsheim	—	3
B. intermedia De Bary	—	3
Chaetophora incrassata (Hudson) Hazen	—	3
Characium sieboldii A. Braun	—	3
†*Chlamydomonas cienkowskii* Schmidle	Pb	—
Cladophora glomerata (L.) Kuetzing	G	3
Closterium acerosum (Schrank) Ehrenberg	Pb	5
†*C. aciculare* Tuffen West	E	—
C. ehrenbergii Meneghini	—	5
C. gracile de Bréb.	—	5
†*C. lanceolatum* Kuetzing	Pb	—
C. leibleinii Kuetzing	PbTBs	5
†*C. lunula* (Muell.) Nitzsch.	Be	—
C. macilentum de Bréb.	Pb	—
C. moniliferum Ehrenberg	Tn	5
C. parvulum var. *angustum* West & West	—	5
C. Subulatum (Kuetz.) de Bréb.	Pb	5
C. venus Kuetzing	Pb	—
C. venus var. *incurvum* (de Bréb.) Krieger	—	5
Coelastrum cambricum Archer	EtcPb	
C. microporum Naegeli	G	3***
C. reticulatum (Dang.) Senn.	Es	—
C. sphaericum Naegeli	—	3
Coleochaete orbicularis Pringsheim	—	3
C. scutata de Bréb.	—	3
C. soluta (de Bréb.) Pringheim	—	3
Cosmarium bireme Nordstedt	—	5
C. birentum var. *minus* Hansgirg	Bs	—
C. dentatum Wolle	—	5
C. fontigenum Nordstedt	—	5
C. formulosum Hoffman	TEBs	—
C. geometricum var. *suecicum* Borge	Pb	—
C. granatum de Bréb.	Tc	—

*1—Jennings (1900)
2—Pieters (1902)
3—Tiffany (1934, 1937)
4—Taft (1942)
5—Taft (1945)
6—Wood (1947)
7—Taft (1964)
8—Taft and Taft (1971)

**Sample Type
B—Benthos
E—Euplankton
G—General in distribution
P—Back water pools
T—Tychoplankton

**Sample Area (see Fig. 1)
b—Beach area
c—Causeway
e—East end
n—North end
r—Boat ramp area
s—South end
w—West end

***Indicated by the authors to be general in distribution in the western Lake Erie area and not specifically listed from East Harbor.
†New records of algae from western Lake Erie.

TABLE 2. *Continued.*

Taxa	1974**	1971 and earlier*
C. humile var. *striatum* (Bolt) Schmidle	TcTs	—
C. leave Rabenhorst	TBsPb	5
C. moniliforme var. *punctata* Lagerheim	—	5
C. phaseolus var. *elevatum* Nordstedt	—	5
C. porrectum Nordstedt	—	5
C. portianum Archer	—	5
C. protractum (Naeg.) De Bary	—	5
C. pseudoprotuberans Kirchner	—	5
C. reniforme (Ralfs) Archer	Es	—
C. seelyanum Wolle	—	5
†*C. sexangulare* f. *minima* Nordstedt	TnPb	—
C. subcrenatum Hantzsch	Tc	—
C. subnudiceps var. *granulatum* Taft	—	5
C. subraciborskii Taft	—	5
C. triplicatum Wolle	—	5
C. variolatum var. *cataractarum* Raciborski	BsTn	—
Crucigenia tetrapedia (Kirch.) West & West	Bs	3
Desmidium swartzii Agardh	—	5
Dichotomosiphon tuberosus (A. Braun) Ernst	—	3
Dictyosphaerium ehrenbergianum Naegeli	E	—
D. pulchellum Wood	E	—
Erenosphaera virdis De Bary	—	3
Euastrum abruptum Nordstedt	—	5
E. abruptum var. *lagoense* (Nordst.) Krieger	—	5
E. bidentatum Naegeli	—	5
E. dubium Naegeli	—	5
E. ohioense Taft	—	5
Eudorina elegans Ehrenberg	—	3
Draparnaldia glomerata (Vauch.) Agardh	—	3
Gloeotaenium loitesbergerianum Hansgirg	—	3
Gloeocystis gigas (Kuetz.) Lagerheim	Tc	—
Haematococcus lacustris (Girod.) Rostaf.	Tn	—
Hyalotheca mucosa (Mert.) Ehrenberg	—	5
Hydrodictyon reticulatum (L.) Lagerheim	PT	—
Kirchneriella contorta (Schmidle) Bohlin	—	3
K. elongata G. M. Smith	—	7
K. obesa (W. West) Schmidle	ErT	3
Micrasterias radiata Hassall	—	5
M. truncata var. *semiradiata* Cleve	—	5
Microspora floccosa (Vauch.) Thuret	—	3
Mougeotia genuflexa (Dillw.) Agardh	—	3
M. spp.	PT	×
†*Oedogonium angustum* (Hirn.) Tiffany	Tc	—
O. capillare (L.) Kuetzing	—	3
O. crenulatocostatum Witteock	—	3
O. crenulatocostatum var. *cylindricum* (Hirn.) Tiffany	—	3
O. echinospermum A. Braun	—	3
O. gracillimum Wittrock & Lundell	—	3
O. howardii G. S. West	—	3
†*O. intermedium* Wittrock	Tc	—
O. moniliforme Wittrock	Bc	3
O. wyliei Tiffany	—	3
O. spp.	G	—
Oocystis borgei Snow	—	3***
O. elliptica W. West	E	—
†*O. gigas* Archer	E	—
Pandorina morum (Muell.) Bory	Pb	—
Pediastrum angulosum (Ehrenb.) Meneghini	—	4
P. biradiatum Meyen	Tc	3
P. boryanum (Turp.) Meneghini	G	3***
P. boryanum var. *longicorne* Raciborski	—	3
P. duplex Meyen	TcPbEr	2
†*P. duplex* var. *clathratum* (A. Braun) Lagerheim	E	3
P. duplex var. *gracilimum* West & West	Er	—
P. duplex var. *reticulatum* Lagerheim	E	—
†*P. duplex* var. *rugulosum* Raciborski	Pb	—
P. integrum Naegeli	Pb	—
P. simplex (Meyen) Lemmermann	E	3
P. simplex var. *duodenarium* (Bailey) Rabenhorst	EPb	—
P. simplex var. *ovatum* (Ehrenb.) Tiffany	Ew	—

TABLE 2. *Continued.*

Taxa	1974**	1971 and earlier*
P. tetras (Ehrenb.) Ralfs	Tc	3***
P. tetras var. *tetraodon* (Corda) Rabenhorst	Pb	3
Penium margaritaceum (Ehrenb.) de Bréb.	—	5
Phacotus lenticularis (Ehrenb.) Stein	—	3
Protococcus viridis Agardh	Tc	—
Pteromonas angulosa (Carter) Lemmermann	—	3
Rhizoclonium heiroglyphicum (Agardh) Kuetzing	PT	3
Scenedesmus abundans (Krich.) Chodat	Pb	3
†*S. abundans* var. *asymmetrica* (Schroed.) G. M. Smith	P	—
S. acuminatus (Lag.)	TcTb	3
†*S. arcuatus* var. *capitatus* G. M. Smith	Tc	—
S. arcuatus var. *platydisca* G. M. Smith	TcEsPb	—
S. armatus (Chod.) G. M. Smith	TcPb	3
S. bernardii G. M. Smith	Bc	3
S. bijuga (Turp.) Lagerheim	TBcE	3***
S. carinatus (Lemm.) Chodat	Pb	—
S. denticulatus Lagerheim	Bc	—
S. dimorphus (Turp.) Kuetzing	TcP	3***
S. longus Meyen	BcPb	—
S. obliquus (Turp.) Kuetzing	—	3***
S. opoliensis P. Richter	Pb	3***
†*S. opoliensis* var. *contacta* Prescott	Tc	—
S. quadricauda (Turp.) de Bréb.	G	3***
S. quadricauda var. *maximus* West & West	Bc	—
Schizomeris leibleinii Kuetzing	Tc	8
†*Selenastrum gracile* Reinsch	ET	—
S. westii G. M. Smith	Pb	—
Sirogonium sticticum (Engl. Bot.) Kuetzing	—	3
Sorastrum americanum (Bohlin) Schmidle	—	3
S. spinulosum Naegeli	—	3***
Sphaerocystis schroeteri Chodat	—	3
Spirogyra crassoidea Transeau	—	3
S. ellipsospora Transeau	—	3
S. juergensii Kuetzing	—	3***
†*S. laxa* Kuetzing	Pr	—
S. longata (Vauch.) Kuetzing	—	3
S. majuscula Kuetzing	—	3
S. protecta Wood	—	3
S. spp.	G	—
Staurastrum bicoronatum var. *tridentatum* Taft	—	5
S. chaetocerus (Schoreder) G. M. Smith	Pb	—
†*S. gracile* Ralfs	E	—
S. paradoxum Meyen	E	—
†*S. paradoxum* var. *parvum* W. West	E	—
S. polymorphym de Bréb.	EP	5
S. sebaldi var. *ornatum Nordstedt*	—	5
S. tetracerum Ralfs	—	5
†*Stigeoconium polymorphum* (Franke) Heering	Tn	—
S. subsecundum Kuetzing	BeTn	3***
†*Tetraedron constrictum* G. M. Smith	Tn	—
T. limneticum Borge	EPb	—
T. minimum (A. Braun) Hansgirg	ErTc	3***
T. regulare Kuetzing	—	3
Tetraspora gelatinosa (Vauch.) Desvaux	Bs	—
Trochisia aspera (Reinsch) Hansgirg	—	3
†*T. obtusa* (Reinsch) Hansgirg	Tc	—
†*Ulothrix subtilissima* Rabenhorst	Tc	—
Westella botryoides (W. West) de Wildemann	Bc	3***
W. linearis G. M. Smith	—	3
Zygnema insigne (Hass.) Kuetzing	—	3
Z. vaucherii Agardh	—	3
Z. spp.	G	—
Charophyta		
Chara Braunii Gmelin	—	2
C. braunii f. *schweinitzii* (A. Braun) R. D. Wood	Pr	2
C. globularis (Desv.) R. D. Wood	—	2
C. vulgaris L. emend. Wood & Imahori	Pb	—
C. zeylanica var. *sejuncta* (A. Braun) R. D. Wood	—	2
C. zeylanica f. *michauii* (A. Braun) H. & J. Gr.	—	2,6
Nitella acuminata f. *subglomerata* (A. Braun) R. D. Wood	—	2,6

TABLE 2. *Continued.*

Taxa	1974**	1971 and earlier*
N. furcata (A. Braun) R. D. Wood	—	2
N. gracilis var. *confervacea* de Bréb.	—	2
N. megacarpa (T. F. A.) R. D. Wood	—	2,6
N. tenuissima (Desv.) Kuetzing	—	2,6
Chrysophyta		
Dinobryon sertularia Ehrenberg	—	1
Mallomonas caudata Iwanoff	BcE	—
Rhizochrysis limnetica G. M. Smith	E	—
Vaucheria terrestris (Vauch.) DeCandolle	—	3
Euglenophyta		
Euglena acus Ehrenberg	Pr	—
†*E. gracilis* Klebs	PETN	—
†*E. oxyuris* var. *minor* Prescott	EP	—
†*E. proxima* Dangeard	Pb	—
E. viridis Ehrenberg	—	1
†*Lepocinclis acuta* Prescott	Pb	—
†*L. playfairiana* Deflandre	Dr	—
Phacus curvicauda Swirenko	TcBc	—
P. longicauda (Ehrenb.) Dujardin	Pb	3
P. nordstedtii Lemmermann	Pb	—
†*P. orbicularis* var. *caudatus* Skvortzow	Pb	—
P. pleuronectes (Muell.) Dujardin	Pbr	—
†*P. pseudoswirenkoi* Prescott	Pb	—
†*P. segretii* Allorge & Lefevre	Bc	—
†*P. spirogryra* Drezepolski	Pb	—
P. triqueter (Ehrenb.) Dujardin	—	1
Trachelomonas armata (Ehrenb.) Stein	—	3
†*T. abrupta* (Swir.) Deflandre	Tc	—
T. gibberosa Playfair	Es	—
†*T. hispida* var. *papillata* Skvortzow	Pr	—
†*T. pulcherrima* var. *minor* Playfair	Pb	—
†*T. robusta* Swirenko	P	—
†*T. suberba* (Swir.) Deflandre	TcPb	—
T. volvocina Ehrenberg	P	3
Pyrrhophyta		
Ceratium hirundinella (Muell.) Dujardin	ET	3***
†*Glenodinium borgei* (Lemm.) Schiller	E	—
†*G. gymnodinium* Penard	E	—
G. pulvisculus (Ehrenb.) Stein	BsTcPb	—
†*Peridinium cinctum* (Muell.) Ehrenberg	E	—
P. tabulatum Ehrenberg	—	1
†*P. wisconsinense* Eddy	E	—
Cyanophyta		
Anabaena catenula (Kuetz.) Bornet & Flahault	—	3
†*A. helicoidea* Benard	E	—
†*A. inaequalis* (Kuetz.) Bornet & Flahault	Pr	—
†*A. macrospora* Klebahn	Es	—
†*A. scheremetievi* Elenkin	Es	—
†*A. torulosa* (Carm.) Lagerheim	Pb	—
†*A. wisconsinense* Prescott	Ew	—
Aphanizomenon flos-aquae (L.) Ralfs	E	3
Aphanocapsa delicatissima West & West	PbE	—
Chamaesiphon incrustans Grunow	Tc	—
Chroococcus limneticus Lemmermann	G	—
†*C. limneticus* var. *distans* G. M. Smith	E	—
C. limneticus var. *purpureus* (Snow) Tiffany & Ahlstrom	—	3
C. minutus (Kuetz.) Naegeli	Pb	3***
C. turgidus (Kuetz.) Naegeli	TcPb	3
Coelosphaerium kuetzingianum Naegeli	—	3
Glaucocystis nostochinearum (Itz.) Rabenhorst	—	4
†*Gloeocapsa aeruginosa* (Carm.) Kuetzing	Ertc	—
Gomphosphaeria aponina Kuetzing	ErPbTc	3
†*G. aponina* var. *delicatula* Virieux	Er	—
G. lacustris Chodat	—	3
†*G. lacustris* var. *compacta* Lemmermann	E	—
Lyngbya aerugineo-caerulea (Kuetz.) Gomont	Tc	—
L. birgei G. M. Smith	—	3
†*L. nordgaardii* Wille	Pr	—
Merismopedia convoluta de Bréb.	Pb	—
M. elegans A. Braun	—	3

TABLE 2. *Continued.*

Taxa	1974**	1971 and earlier*
M. glauca (Ehrenb.) Naegeli	TcPbBc	3
M. punctata Meyen	—	3
M. tenuissima Lemmermann	Pb	3
Microcystis aeruginosa Kuetzing emend. Elenkin	ETc	3
M. incerta Lemmermann	E	—
Nodularia sphaerocarpa Bornet & Flahault	—	3
Oscillatoria acutissima Kufferath	Tc	—
O. agardhii Gomont	G	—
O. amoena (Kuetz.) Gomont	Pb	—
†*O. limnetica* Lemmermann	Bc	—
O. princeps Vaucher	TcPb	3
O. prolifica (Grev.) Gomont	—	3
O. splendida Greville	—	3
†*O. subbrevis* Schmidle	Bc	—
O. tenuis Agardh	TcPb	3***
Phormidium inundatum Kuetzing	Pb	—
P. retzii (Agardh) Gomont	Pb	—
†*P. tenue* (Menegh.) Gomont	Tc	—
Raphidiopsis curvata Fritsch & Rich	—	8
Spirulina princeps (West & West) G. S. West	—	3
Tolypothrix tenuis Kuetzing	—	3

One hundred sixty-one algal taxa were identified during the 1974 study, while 151 taxa were compiled by Taft and Taft (1971). Of the total 265 taxa reported from East Harbor, only 18% (47 taxa) were common to this and all previous studies. Only 31% of the 151 taxa identified before 1974 were present at East Harbor (table 3). Major differences in the algal flora occurred in the epiphytic taxa, desmids, planktonic Chlorococcales, Charophyceae, Euglenophyceae, Dinophyceae, and several genera in the Myxophyceae (table 2).

Very few epiphytic algal taxa were found at East Harbor during this study, while many were reported by Tiffany (1937). *Bulbochaete* spp., *Chaetophora incrassata*, *Characium sieboldii*, *Coleochaete* spp., *Draparnaldia glomerata*, and others were found quite commonly on the abundant submersed macrophytes (Tiffany, 1937). However, none of those taxa were present in the writer's 1974 collections. The absence of these taxa may be attributed directly to the 1967 dredging which destroyed most submersed macrophytes and, therefore, destroyed suitable epiphytic algal substrates.

Fifty-four desmid taxa were recorded

TABLE 3

Taxa reported from East Harbor prior to 1972 as compared to the most recent collection.

Author	No. of Taxa before 1972	No. of Taxa 1974	% Taxa Remaining
Jennings (1900)	6	1	17
Pieters (1902)	10	1	10
Tiffany (1934, 37)	93	37	40
Taft (1942)	2	0	0
Taft (1945)	36	6	17
Wood (1947)	4*	0	0
Taft (1964)	1	0	0
Taft and Taft (1971)	3	2	67
TOTAL	151	47	31

*Included in Pieters.

from East Harbor in all studies; however, only six taxa (11%) were common both to the 1974 study and to all previous studies. In addition, the genera, *Desmidium*, *Hyalotheca*, *Micrasterias*, *Penium*, and *Euastrum* reported by Taft (1945) were not found in the 1974 collections. As these genera are primarily tychoplankton forms, one might expect that, with the almost total destruction of tychoplankton habitats during the harbor dredging, most tychoplankton forms may have been destroyed. Nearly equal numbers of taxa in the genera, *Closterium*, *Cosmarium*, and *Staurastrum* were identified in this study and in Taft (1945), but only six taxa (14%) were common to both (table 2). These differences possibly may be attributed to the 1967 dredging or, more specifically to the changes in water chemistry in the harbor as a result of that dredging.

A valid comparison between East Harbor water chemistry during earlier collection periods and the present is impossible due to the lack of historical water chemistry data. A theoretical picture of the water chemistry of East Harbor prior to 1967, however, can be obtained utilizing the observations of several investigators. Ruttner (1963) noted that several phenomena coincide with an increased rate of photosynthesis (due to masses of submersed macrophytes) the most evident being increased oxygen concentrations and decreased carbon dioxide concentrations. In addition, in the presence of aquatic macrophytes, concentrations of salts will decrease, while alkalinity and pH will increase according to the principles Ruttner outlined. He further stated that, "in sunlit pools with luxuriant submersed vegetation [a situation found in East Harbor until 1967] . . . the pH can be raised up to about 11." Fitzgerald (1969) postulated that mats of submersed macrophytes such as *Potomogeton* and *Ceratophyllum* may act as nitrogen sinks, limiting the available nitrogen for the plankton algae. Both Ruttner and Fitzgerald suggested that, in the presence of abundant aquatic macrophytes, the complete disappearance of nitrates in eutrophic lakes is not unusual. Hutchinson and Bowen (1947) found that concentrations of phosphorus are similarly affected.

Welch (1952) noted several other effects that abundant submersed macrophytes had on aquatic environments. He stated that, "removal of larger submersed plants from a lake results in increased and continued turbidity of the water." This phenomenon was confirmed earlier for East Harbor by previous investigators who indicated that the water was always quite clear when they collected the harbor. Water transparency for the harbor during my study was rarely greater than one meter. Welch also noted that large mats of aquatic plants function in the reduction of local wave action, a factor that may affect shoreline algae and, perhaps, algal epiphytes on the few submersed aquatics remaining in East Harbor.

Assuming that the above phenomena have occurred in East Harbor, the picture of pre-1967 water chemistry is radically different than that of the present. One would expect that the oxygen concentration, alkalinity, and pH were greater prior to 1967, while carbon dioxide, salts, nitrogen, and phosphorus concentrations (in addition to local wave action and turbidity) were less in the harbor before dredging. Any one of those factors could have a great effect on the composition of the algal flora, as nutritional and other requirements vary with different algal taxa.

Other factors may account for the fivefold increase in the Euglenophycean taxa encountered during this study. As reflected in table 2, most representatives in that class were collected from very shallow backwater pools in the beach area. This area was created during the 1967 dredging as the suction-dredge material was deposited on the harbor side of the old beach area (Moore, 1973). The pools resulted from the recent high water levels of Lake Erie and were lacking during the previous studies of East Harbor (fig. 1).

The more complete data available on the Charophyceae of East Harbor provide a better overview of the changes that have occurred in that algal class during the past seventy-five years. Pieters (1902) reported five *Chara* taxa and five *Nitella* taxa, while Wood (1947)

reported only *Chara zeylanica* f. *michauii*, *Nitella acuminata* f. *subglomerata*, *N. megacarpa*, and *N. tenuissima* (all four were reported by Pieters, 1902). *Chara* spp. and *Nitella* spp. made up a good deal of the submersed flora of the harbor during the early 1940's. Only *C. braunii* f. *schweinitzii* and *C. vulgaris*, however, were identified in the 1974 collections, and those taxa were found only in the shallow backwater pools and not in the harbor proper. Deepening of the harbor and destruction of existing *Chara* taxa during the 1967 dredging can account for the more recent changes in the Charophyceae of East Harbor. Charophyceae flora changes occurring between the studies of Pieters and Wood cannot be adequately accounted for, as Moore (1973) records no man-induced disturbances during that interval. Some mowing of the aquatic vegetation in the early 1940's has been reported but the extent of the mowing is not known.

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