Indicator: Reestablishment of Long-Absent Aquatic Macrophytes in Western Lake Erie

Background

The first well-documented survey and inventory of the aquatic plants, or macrophytes, in Lake St. Clair was conducted by Adrian J. Pieters (1894). The methodology developed in that study was incorporated in a much larger survey conducted in western Lake Erie from 1898-1901. These studies were part of a systematic inventory of the biology of the Great Lakes for the U.S. Department of Agriculture focusing primarily on fish production and their food sources (Stuckey 1988; 1989). Edwin Moseley's Sandusky Flora (1899) also lists the aquatic macrophytes he encountered in his surveys. These two works, along with the notes, collections, and observations of William Kellermann, Otto Jennings, John Schaffner, Paul Sears, David Stansbery, and Earl Core, provide additional descriptions of the aquatic macrophyte flora of the western Lake Erie basin (Stuckey 1989). From these descriptions of the habitats visited by Pieters and others, we have a long-term perspective of the dramatic changes in the aquatic macrophyte communities for more than a century. Ronald Stuckey and a number of students examined the species composition and distribution of plants in the region, and assessed changes in a number of sites in the western basin of Lake Erie and associated wetlands (Stuckey 1971; 1989). Since 1995, David Moore has systematically documented the relatively rapid changes in the composition of the submersed aquatic macrophytes near the southern shore of western Lake Erie in the Put-in-Bay area.

Status and Trends

Pieters (1901) recorded 40 taxa of aquatic macrophytes at Put-in-Bay in 1898, eight of which were not reported in Earl Core's 1940 survey:

Potamogeton amplifolius	Large-leaved Pondweed
Megalodonta beckii	Water Marigold
Potamogeton friesii	Fries' Pondweed
Najas guadalupensis	Guadalupe Naiad
Potamogeton praelongus	White-stemmed Pondweed
Scirpus expansus	Wood Bulrush
Potamogeton perfoliatus	Clasping-leaved Pondweed
Carex aquatilis	Water Sedge

By 1949, Core reported that an additional six had disappeared:

Potamogeton filiformis	Slender-leaved Pondweed
Potamogeton nodosus	Long-leaved Pondweed
Potamogeton gramineus	Variable-leaved Pondweed

Nuphar advena	Spadderdock
Potamogeton natans	Floating Pondweed
Sagittaria rigida	Broad-leaved Arrowleaf

And by 1957, Stansbery reported that another six taxa had disappeared (Stuckey 1989):

Potamogeton pusillus ssp. *tenuissimus*	Narrow-leaved Pondweed
Najas flexilis	Slender Naiad
Potamogeton foliosus	Leafy Pondweed
Nymphaea tuberosa	White Waterlily
[Nymphaea odorata ssp. *tuberosa]*	
Potamogeton zosteriformis	Flat-stemmed Pondweed
Elodea canadensis	Canadian Waterweed

What happened in the intervening 69 years? Stuckey surveyed Put-in-Bay in 1967 when he began to teach his aquatic plants course at F.T. Stone Laboratory of Ohio State University, confirming Stansbery's observations (Figure 1):

a. 20 of the 40 original taxa had disappeared = 50%

b. 11 of the 20 were of northern distribution = 55%

If we consider only suspended and submersed taxa noted by Pieters (22 of 40), the number of taxa lost from the waters of Put-in-Bay is 16 of the 22, or 73%. Increased nutrients (principally phosphate and nitrate) from fertilizer and sediment runoff on South Bass Island in Put-in-Bay caused algal blooms and increased suspended sediment. The decomposing algae decreased the amount of oxygen in the water and the suspended sediment reduced light available for plant growth (Figure 2). Of the 16 suspended and

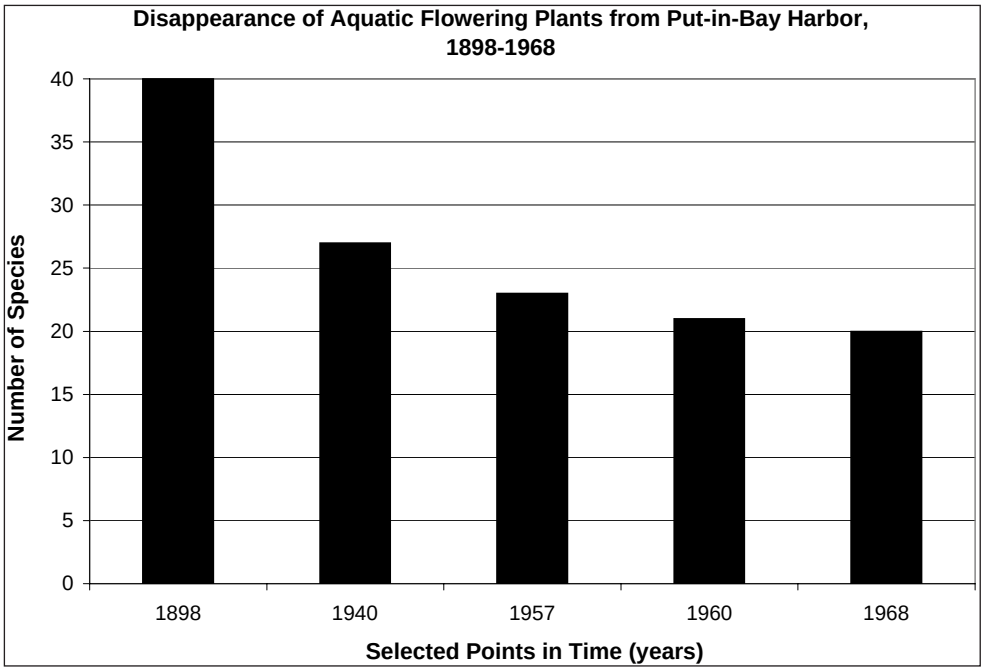

Figure 1. Ronald Stuckey's overview showed a 50% loss of aquatic macrophyte diversity by 1968 (adapted from Stuckey 1971).

Figure 2. Algal blooms were common in 1972 (Photo credit: Ronald Stuckey).

submersed taxa lost from Put-in-Bay, 12 are of northern distribution, which at Put-in-Bay are at their southernmost limit, and "sensitive" to stressful environmental conditions.

Of the other 18 (emergent) taxa reported by Pieters (1901), nine have widespread distributions. These taxa are generally tolerant of turbid, warmer water, and would be expected to endure in Put-in-Bay Harbor, although *Carex aquatilis* (water sedge) did disappear. Figure 3 displays all 40 aquatic macrophytes from Pieters (1901) showing the significant decline of species with northern distribution (81%), southern distribution (50%), and the more tolerant species with widespread distributions (only 19%). An additional five new taxa, also generally tolerant of turbid, warmer water, have arrived since Pieters' 1898 study:

Potamogeton crispus	Curly Pondweed
Elodea nuttallii	Nuttall's Waterweed
Myriophyllum spicatum	Eurasian Water-milfoil
Butomus umbellatus	Flowering Rush
Potamogeton pusillus ssp. *tenuissimus*	Narrow-leaved Pondweed

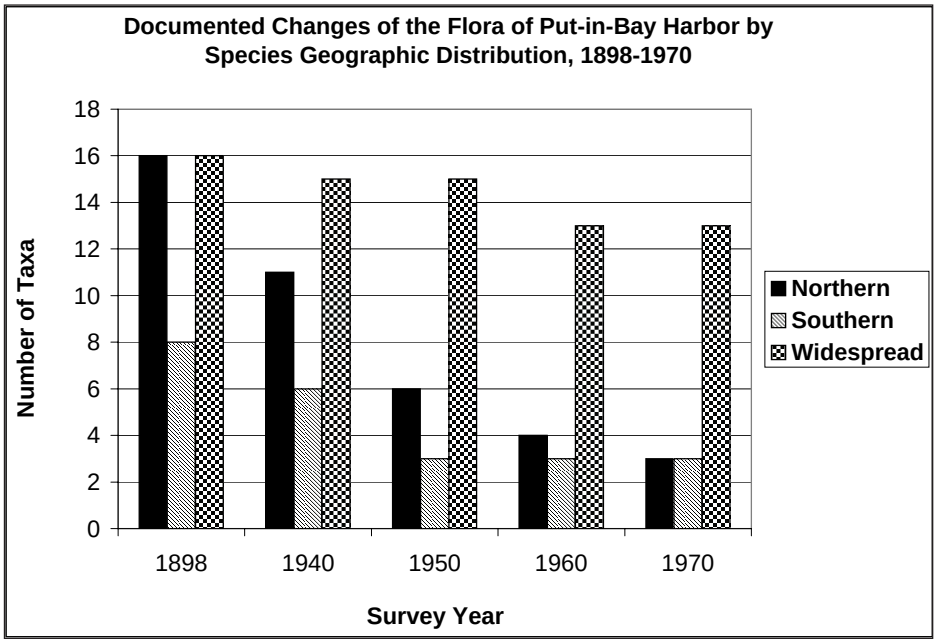

Figure 3. Documented changes of the 40 aquatic macrophytes Pieters (1901) listed from Put-in-Bay Harbor, Lake Erie, Ohio, compiled from literature, herbarium records, and surveys with northern, southern, and widespread distribution. Species with northern distribution are those at the edge of their range and are therefore susceptible to environmental change and had declined the most. See Attachment 1 at the end of this indicator for species-specific data.

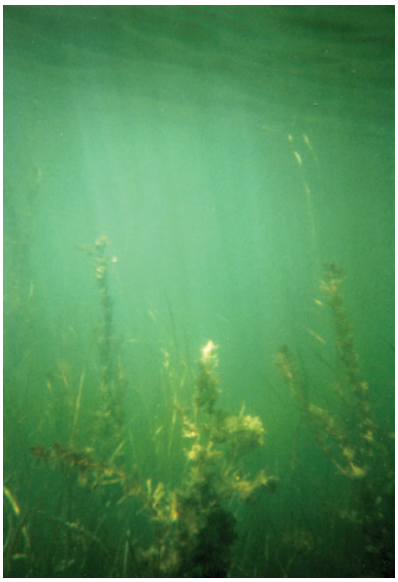

Figure 4. Light availability in Hatchery Bay, at three meters depth showing Myriophyllum *(Photo taken in ambient light by David Moore).*

In summer 1985, the open water of Put-in-Bay had relatively low diversity with only six dominant taxa and an additional two taxa found only occasionally within the harbor:

Stuckenia pectinatus	Sago Pondweed	Dominant
Zosterella dubia	Water Stargrass	
Myriophyllum spicatum	Eurasian Water-milfoil	
Ceratophyllum demersum	Coontail	
Potamogeton pusillus ssp. *tenuissimus*	Narrow-leaved Pondweed	
Potamogeton crispus	Curly Pondweed	
Vallisneria americana	Wild Celery	Occasional
Elodea canadensis	Canadian Waterweed	

Long-term water transparency data indicated a dramatic increase in light penetration between Stuckey's 1968 survey and a 1994 Put-in-Bay survey led by David Moore and his students (Table 1 and Figure 4). There was a dramatic increase in light availability since 1985 and this was a primary factor causing change in the submersed macrophyte community structure. Wild celery (*Vallisneria americana*) according to Stuckey (1968) was an uncommon plant, but by 1994, it dominated the community structure and was considered by some locals to be a "weed" by 1994. In addition, seven taxa originally reported by Pieters, but absent since 1951, had returned to Put-in-Bay Harbor (Figure 5).

Table 1. Water transparency data summary (adapted from Stuckey and Moore 1995).

Mean Secchi disk values (m) for the western basin of Lake Erie and Put-in-Bay Harbor, Ohio.								
Month	1967-1982[1]	1988[2]	1988-1990[3]	1990[4]	1991	1992	1993	1994
March	-		-	-	1.29	2.56	2.02	1.90
April	-		-	1.00	.90	3.69	1.55	1.83
May	-		-	1.82	2.65	3.92	2.06	2.14
June	-		-	2.11	2.80	3.17	2.92	3.40
July	-		-	2.79	3.32	3.18	3.14	3.58
August	-		-	3.44	3.42	3.05	3.70	3.93
Sept.	-		-	3.90	3.33	3.29	3.94	3.76
Oct.	-		-	2.87	3.59	2.83	2.55	3.61
Nov.	-		-	1.37	2.47	-	-	-
Annual	.80		2.10	2.42	2.64	3.21	2.74	3.02

[1] Data for 1967-1982 from Bolsenga and Herdendorf (1993).
[2] Year of zebra mussel introduction.
[3] Data for 1988-1990 (May-November each year) from Leach (1993).
[4] Data for 1990-1994 (unpublished) from J. Hageman, Manager of F.T. Stone Laboratory, Put-in-Bay, Ohio.

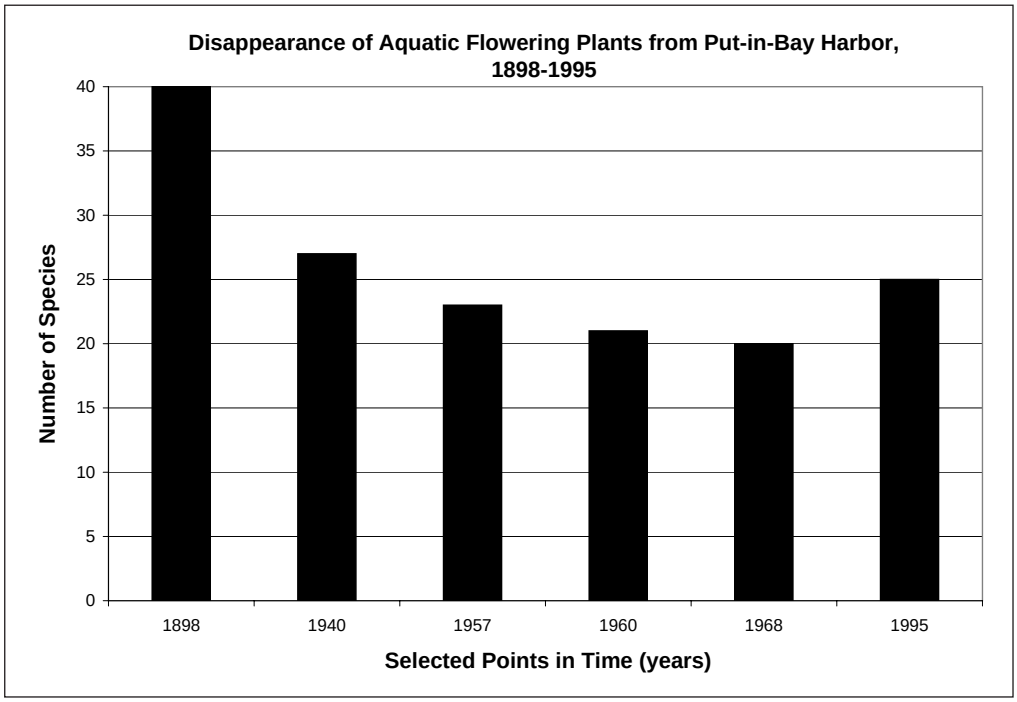

Figure 5. Revision of Stuckey's 1968 graph shows the increase in species of aquatic macrophytes that had returned by 1995 (adapted from Stuckey and Moore 1995).

Since 1995, there have been additional submersed aquatic macrophytes returning to Put-in-Bay. In 2006, two additional taxa were rediscovered in Hatchery Bay: *Potamogeton nodosus* was growing in substantial colonies in 1.5 meters of water, and one large colony of *Potamogeton zosteriformis* was observed growing near the Ohio State University docks (Moore 2006a). In addition, a 38 cm stem segment with leaves and a cluster of flowers of *Potamogeton illinoensis* was also discovered near the Ohio State University docks (Figure 6). With the continued water clarity, recolonization of the waters around Put-in-Bay by additional taxa is not unexpected. Whether the *P. illinoensis* will establish as reproducing components of the submersed aquatic macrophyte flora remains to be seen. There is concern regarding the increased algal blooms of mostly *Cladophora* and cyanobacteria in Put-in-Bay Harbor (Figure 7). What impact that will have on the submersed macrophyte community is uncertain at present.

Potamogeton zosteriformis
Flat-stemmed Pondweed

Potamogeton illinoensis
Illinois Pondweed

Potamogeton nodosus
Long-leaved Pondweed

Figure 6. Newly returned taxa at Put-in-Bay Harbor (Photo credits: David Moore).

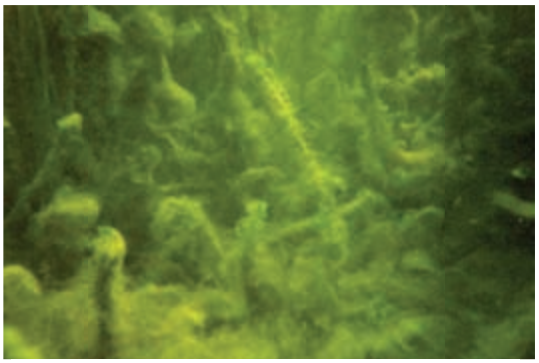

Figure 7. Colonization of submersed aquatic macrophytes by Cladophora *in summer 2006 (Photo credit: David Moore).*

Management Next Steps

Priority should be placed on controlling inputs of nonpoint pollutants, especially phosphorus. Further, a higher priority needs to be placed on stopping the entry of invasive species. Finally, more effort should be focused on coupling research, monitoring, and management.

Research/Monitoring Needs

Ongoing monitoring, especially of the submersed macrophyte flora in the waters of western Lake Erie, is crucial to understanding the changes taking place and their consequences on fisheries and benthic production. Additional aquatic macrophyte monitoring sites need to be established to assess the shifting composition of the submersed aquatic flora and the associated benthic communities. For instance, the large reproducing colonies of *P. nodosus* and *P. illinoensis* that were observed near the State Park docks on South Bass Island were previously known to be only occasionally found in Fox's Marsh on North Bass Island and in West Quarry on Kellys Island. They have since disappeared from Fox's Marsh because of invasive forms of *Phragmites australis*. Another pondweed, *P. richardsonii*, had almost disappeared by 1951, but since 1994 has been rapidly expanding and establishing numerous additional locations within Put-in-Bay Harbor, as well as along the south sides of South, Middle, and North Bass Islands (Moore 2006b). In addition, emergent shoreline taxa have become less common (or even rare) because of extensive shoreline development. Further monitoring will allow us to understand these changes that ultimately reflect the status and the health of the entire aquatic ecosystem of the western Lake Erie basin.

References

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Links for More Information

Franz Theodore Stone Laboratory: http://ohioseagrant.osu.edu/stonelab/

Bibliography of research at Stone Lab 1895-1968: https://kb.osu.edu/dspace/bitstream/1811/5602/1/V71N02_081.pdf

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Attachment 1

Documented changes of the 40 aquatic macrophytes Pieters (1901) listed from Put-in-Bay Harbor, Lake Erie, Ohio, compiled from literature, herbarium records, and surveys; a – l. (+ = present; R = rare; O = occasional; C = common; A = abundant; SA = super abundant; W = widespread; ? = species status unknown; --> = no direct data, but presumed continuation in place). Adapted and expanded from Stuckey and Moore 1995.*

			1900	1925	1940	1950	1955	1960	1965	1970	1975	1980	1985	1990	1995	2000	2005	2006
	Submersed or Emergent	Geographic Distribution	a.	b.	c.	d.		e.		f.		g.	h.	i.	j.	k.	l.	m.
Potamogeton amplifolius	S	N	+															
Potamogeton friesii	S	N	O															
Potamogeton praelongus	S	N	+															
Potamogeton perfoliatus	S	N	+															
Megalodonta beckii	S	N	+															
Najas guadalupensis	S	S	+									+	+	R	O	O	O	R
Scirpus expansus	E	S	+															
Carex aquatilis	E	W	+															
Potamogeton filiformis	S	N	R	--->	+													
Potamogeton gramineus	S	N	C	--->	+													
Potamogeton natans	S	N	+	--->	+													
Sagittaria rigida	E	N	C	--->	+													
Potamogeton nodosus	S	S	+	--->	+												O	O
Myriophyllum exalbescens	S	N	C	--->	+													
Nuphar advena	E	S	C	--->	+										R	R	R	?
Potamogeton pusillus ssp. *pusillus*	S	W	A	--->	+	A								C	C	C	C	A
Potamogeton foliosus	S	N	+	--->	+	+								+	O	C	O	O
Nymphaea odorata ssp. tuberosa	E	S	+	--->	+	C							+	+	+	+	+	+
Elodea canadensis	S	W	C	--->	+	+	+						O	O	C	O	R	R
Najas flexilis	S	N	A	--->	+	A	+							+	R	R	R	O
Potamogeton zosteriformis	S	N	A	--->	+	C	--->	+										+
Typha latifolia	E	W	+	--->	+	--->	--->	--->	--->	R	--->	--->	R	R	R	R	?	?
Nelumbo lutea	E	S	+	--->	+	+	--->	--->	--->	R	--->	--->	R	R	?	R	?	?
Potamogeton richardsonii	S	N	A	--->	+	A	+	--->	--->	R	--->	--->	O	O	C	C	C	A
Zannichellia palustris	S	W	R	--->	+	R	--->	--->	--->	R	--->	--->	O	R	R	R	O	R
Justicia americana	E	S	+	--->	+	+	--->	--->	--->	R	--->	--->	R	R	R	R	R	R
Carex comosa	E	W	+	--->	--->	--->	--->	--->	--->	R	--->	--->	R	R	R	R	R	R
Scirpus acutus	E	N	+	--->	+	O	--->	--->	--->	R	--->	--->	O	O	O	O	O	O
Scirpus pungens (= americanus)	E	W	C	--->	+	O	+	--->	--->	R	--->	--->	O	O	O	O	O	R
Juncus torreyi	E	W	+	--->	--->	--->	--->	--->	--->	R	--->	--->	R	R	?	?	?	?
Scirpus atrovirens	E	W	+	--->	--->	--->	--->	--->	--->	O	--->	--->	R	R	R	R	R	R
Scirpus fluviatilis	E	N	+	--->	+	--->	--->	--->	--->	O	--->	--->	--->	--->	O	O	R	R
Rumex verticillatus	E	S	+	--->	+	--->	--->	--->	--->	O	--->	--->	--->	--->	O	O	R	R
Sparganium eurycarpum	E	W	+	+	+	--->	--->	--->	--->	O	--->	--->	--->	--->	O	R	R	R
Asclepias incarnata	E	W	C	--->	+	--->	--->	--->	--->	O	--->	--->	--->	--->	O	R	R	R
Sagittaria latifolia	E	W	+	--->	+	--->	--->	--->	--->	O	--->	--->	--->	--->	O	O	O	O
Zosterella dubia (= Heteranthera dubia)	S	W	A	--->	+	C	+	--->	--->	O	--->	--->	--->	--->	C	C	C	C
Potamogeton pectinatus	S	W	A	--->	+	A	--->	--->	--->	O	--->	--->	--->	--->	O	O	O	O
Ceratophyllum demersum	S	W	C	--->	+	A	+	--->	--->	O	--->	--->	--->	--->	C	C	C	C
Vallisneria americana	S	W	+	--->	+	A	+	--->	--->	A	--->	--->	C	A	SA	SA	SA	SA

Blank cells indicate absence of species

* Documented records:

a. Original survey by A.J. Pieters, 1898 (published 1901).
b. Records from Stehle, 1920; Kennedy, 1923; Shawver, 1931; Tiffany, 1933; Krecker, 1935.
c. Records from Doan, 1941; Core, 1948.
d. Records from Core, 1949; McQuate, 1952.
e. Records from Pinkava, 1959; Stansbery, 1957; Daniel, 1963.
f. Records from Stuckey, 1956-1970.
g. Records from Dorazio, 1978.
h. Records from Moore, 1985.
i. Records from Joseph, 1988; Burgess, 1989.
j. Records from Stuckey and Moore, 1995.
k. Records from Moore, 2000.
l-m. Records from Moore (ongoing surveys).