Evidence of Walleye Spawning in Maumee Bay, Lake Erie[1]

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Abstract. **During the mid-1990s, anglers reported large numbers of walleye (*Stizostedion vitreum*) in spawning condition concentrated on shallow points adjacent to the Maumee River channel during spring. These fish had flowing eggs and semen and were suspected to be actively spawning in Maumee Bay. To investigate the potential of walleye spawning, we used a benthic pump to sample for eggs at five sites adjacent to the Maumee River channel and one site near Turtle Island in Maumee Bay on 5 April 1998, a time when walleye were actively spawning in rivers and on mid-lake reefs. We found walleye eggs at each of the six sites sampled. Relative abundance of eggs ranged from 17 to 2,105 per 2-min sample, with a mean of 459 (±232). Egg viability ranged from 33 to 54% across the sites and 10% of the viable walleye eggs were observed to be in late stages of embryonic development indicating that egg survival to hatching is likely. These results are the first documentation of walleye spawning in Maumee Bay, indicating that Maumee Bay is a viable spawning location for walleye, possibly representing an important source of recruitment for the Lake Erie stock.**

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INTRODUCTION

In the late 19th century, Wakeham and Rathbun (1897) referred to Maumee Bay as the most prolific spawning grounds for many important fish species in all of Lake Erie. By 1930, however, the fish spawning habitat of Maumee Bay became highly degraded due to industrial pollution, eutrophication, siltation, and associated low dissolved oxygen levels (Wright 1955). Conditions in Maumee Bay mirrored conditions in the other areas of the Lake Erie basin. The degraded habitat conditions, coupled with over-exploitation, contributed to the dramatic decline of the walleye (*Stizostedion vitreum*) population in the lake by the late 1950s. Discrete stocks of walleye were nearly eliminated from previously prolific spawning areas such as the Cuyahoga, Maumee, and Sandusky rivers and bays (Schneider and Leach 1977; Hatch and others 1987).

The passage of the Great Lakes Water Quality Agreement in 1972 facilitated habitat rehabilitation efforts and, coupled with the closure of the walleye fishery from 1970-72, led to improved walleye recruitment and significant increases in walleye numbers (Hatch and others 1987). The formation of several strong walleye year-classes coupled with restrictive management programs helped increase the population to more than 100 million harvestable age-2 and older fish by 1988. Current levels (2001) are estimated at approximately 40 million fish (Turner and others 2001). Reproducing stocks of walleye were flourishing again in most historic spawning locations in Lake Erie and its tributaries.

Since the mid 1990s, anglers have observed large concentrations of adult fish in spawning condition in the shallow areas adjacent to the Maumee River channel each spring, suggesting that walleye were using these areas to spawn. Anglers reported catching large numbers of female walleye with ripe eggs and ejaculating males. These observations were similar to those made by commercial fishermen in Maumee Bay prior to 1957, but no verification of these early observations was ever made (Pinsak and Meyer 1976). In 1998, walleye anglers in Maumee Bay provided researchers at the Ohio Department of Natural Resources, Division of Wildlife, and Michigan State University with specific locations where they suspected walleye were spawning along the Maumee River channel in Maumee Bay. In this paper, we present the first documented evidence that verifies angler observations of walleye spawning in Maumee Bay.

MATERIALS AND METHODS

To determine if walleye were spawning in Maumee Bay, the authors sampled six potential spawning sites along the Maumee River channel (Fig. 1) during mid-day on 5 April 1998 using a benthic pump. We recorded depth (m), water temperature (° C), and substrate composition at each sample site to provide characteristics of the habitat (Table 1). Substrate composition was determined in three ways: surface visual analysis (Platts and others 1983); visual assessment of substrate particles collected with eggs; and surrogate estimation of particle type (that is, hard or soft bottom) by tactile probing with a pole.

The benthic pump consisted of a 39 kg iron sled that was attached to a diaphragm pump at the surface by a flexible 5.0 cm diameter hose (Stauffer 1981; Roseman and others 1996). This collection method was effective for sampling demersal walleye eggs on mid-lake reefs in western Lake Erie and induced no damage or mortality to walleye eggs (Roseman and others 1996, 2001). Because walleye are known to spawn over the shallowest points on mid-lake reefs (Roseman and others 1996, 2001), we directed our sampling effort on the shallowest

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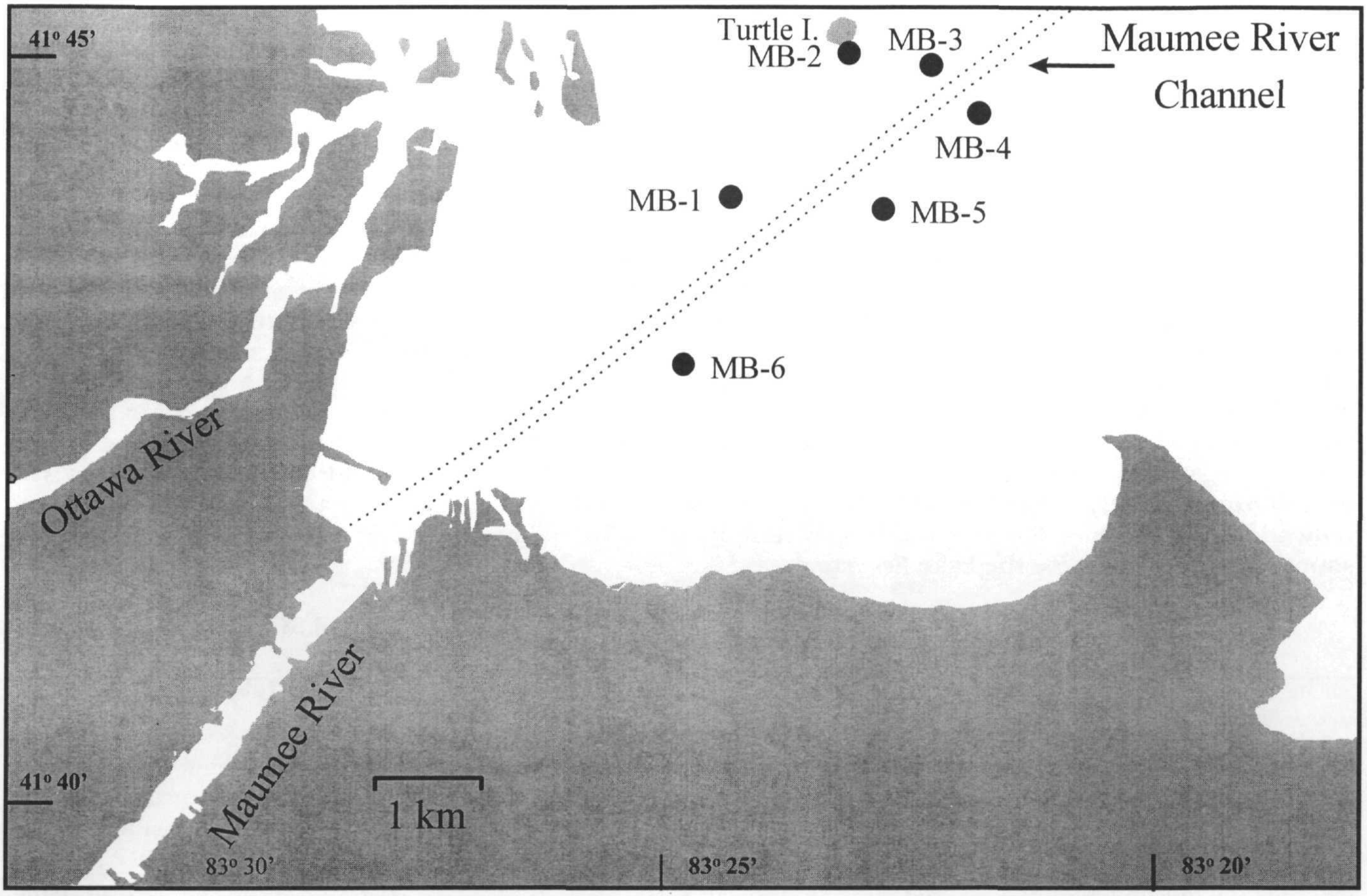

FIGURE 1. Map of Maumee Bay identifying sites sampled with egg pump on 5 April 1998 (•).

points at the locations suggested by angler observations. We collected three replicate samples at each site by towing the sled for 2.0 min at about 0.5 m/sec. Eggs and benthic debris (Dreissenid mussels and shells, sand, benthic organisms) were deposited into a 0.5 m^3 basket lined with 0.5 mm^2 mesh netting. The net liner containing the sample was then removed and placed in a labeled plastic bag. Samples were refrigerated at 5° C until they could be sorted at the laboratory, which occurred approximately three hours after collection. In the laboratory, samples were rinsed through a galvanized steel wire screen (6.0 mm bar mesh) to separate large debris from finer particles and eggs. The remaining small particulate matter was then examined for walleye eggs. Identification of eggs was based on egg diameter (mm), egg color, and subsequent hatching of eggs (Roseman and others 1996). Hatched larvae were identified according to Auer (1982). Collected eggs were examined with 10× magnification to assess egg viability. All eggs that were ruptured or showed signs of opaqueness or

TABLE 1

Coordinates of egg collection sites in Maumee Bay, depth, and bottom substrate type for each site sampled on 5 April 1998.

Site #	Latitude	Longitude	Depth (m)	Substrate
MB-1	N 41° 44.000'	W 83° 24.050'	2.0-3.0	Sand/Dreis*
MB-2	N 41° 45.090'	W 83° 23.300'	2.5-4.0	Sand/Rock/Dreis
MB-3	N 41° 44.786'	W 83° 22.359'	2.0-3.0	Sand/Dreis
MB-4	N 41° 44.575'	W 83° 21.012'	2.5-4.0	Sand/Dreis
MB-5	N 41° 44.127'	W 83° 21.920'	2.5-4.0	Sand/Dreis
MB-6	N 41° 43.040'	W 83° 24.325'	2.0-3.0	Sand/Dreis

*Indicates Dreissenid mussels and shells.

fungal growth were classified as dead eggs. All clear or eyed eggs were classified as viable eggs. We calculated the average number of eggs collected per tow and standard deviation of the mean at each sample site (Snedecor and Cochran 1989).

To assess potential egg survival in Maumee Bay, viable walleye eggs were classified by developmental stage (Nelson 1968; Hurley 1972; McElman and Balon 1979) using a compound microscope with variable magnification. Stage 1 eggs were pre-organogenesis stage, while stage 3 eggs were late embryonic stage with developed eyes, pectoral fin buds, and caudal mesenchyme rays as well as chromatophores along the ventral line and yolk sac. Stage 2 eggs showed intermediate development with undeveloped eyes and lacked fin buds and mesenchyme rays.

RESULTS AND DISCUSSION

Large numbers of viable walleye eggs were collected, verifying that walleye spawned in Maumee Bay in 1998. Walleye egg numbers ranged from 17 to 2,105 per 2-min tow with a mean of 459 (±232) per tow (Table 2). The greatest number of eggs was collected from site MB-2 located on the fringe of Turtle Island (Fig. 1), where a mean of 1,009 (±179) walleye eggs was collected per tow (Table 2). The larger substrate particles at this site may have retained eggs better than the sandy substrates common to other sampling sites in Maumee Bay. The fewest eggs were collected from sites MB-1 and MB-4 along the edge of the Maumee River channel, which averaged only 130 (±94) eggs per tow (Table 2). These catch rates were somewhat lower than those on mid-lake reefs during this same time period where egg numbers ranged from 540 on Cone reef to 2,582 on Toussaint reef (Roseman 2000; Roseman and others 2001).

Egg viability in Maumee Bay ranged from 33 to 54% across the sites (Table 2) and was within the range of viability estimates (18 to 63%) observed on mid-lake reefs in western Lake Erie during the same time period (Roseman 2000). About 10% of the viable walleye eggs collected in Maumee Bay were observed to be stage 3 of embryonic development. Based on reported temperature dependent development rates (Allbaugh and Manz 1964; McElman and Balon 1979), we estimated that these late embryonic stage eggs would hatch within 3 days at the current water temperature in Maumee Bay (8.3 to 10.2° C; Table 2). Therefore, survival of eggs from deposition to hatching was probable in Maumee Bay. Eggs collected at the same time from mid-lake reefs were in early stages of development (stage 1 and 2; Roseman 2000), suggesting that the eggs in Maumee Bay were spawned earlier than those on offshore reefs. Additionally, water temperatures in Maumee Bay ranged from 8.3 to 10.2° C, and temperatures on the reefs ranged from 6.9 to 7.9° C (Roseman 2000). Because initiation of spawning and embryonic development are temperature dependent (Allbaugh and Manz 1964), the warmer water temperatures in the bay contributed to earlier spawning or faster development than that incurred by eggs on the reefs. Fast development and hatching should minimize vulnerability to egg predators and provide a competitive advantage over other fish still in the egg stage (Wolfert and others 1975).

In Lake Erie, walleye typically spawn on rocky mid-lake reefs and in gravel stretches of tributary rivers (Baker and Manz 1971; Hatch and others 1987; Roseman and others 1996; Roseman and others 2001). Based on our observations, bottom substrates at all sampling sites in Maumee Bay, except MB-2, appeared to consist of sand and Dreissenid mussels and shell fragments. Site MB-2 is located along the fringe of Turtle Island and has variable substrate composition consisting of larger and harder substrate components (estimated to be cobbles and small boulders) than the other sites, in addition to Dreissenid mussels and shell fragments (Table 1). Based on existing bathymetric maps (NOAA 1991) and the large amount of sand collected during sampling, we surmised that the mounds in Maumee Bay where we found walleye eggs were composed mostly of sand and soft sediment overlain with Dreissenid mussels and shells (Table 1).

Walleye in other systems are known to use soft substrates and vegetated zones as spawning sites with successful recruitment. For example, Priegel (1970) reported that walleye spawned on mats of vegetation and over areas of exposed mud in marshes adjacent to Lake Winnebago, WI. Similarly, Johnson (1961) found that eggs spawned on soft muck-detritus substrates survived in Lake Winnibigoshish, MN. Similar to the spawning areas we found in Maumee Bay, these spawning areas had flowing water with minimal sedimentation and provided adequate dissolved oxygen for incubating walleye eggs.

Mean catch per effort of walleye eggs in Maumee Bay was somewhat lower than catches from western Lake Erie reefs during the same time period. Catches of walleye eggs from reefs on 6 April 1998 ranged from 540 to

TABLE 2

Number of walleye eggs collected from sites in Maumee Bay on 5 April 1998.

Site #*	Depth (m)**	Bottom Temperature†	Number of Eggs‡	Viability (%)§
MB-1	2.0-3.0	9.9	130 (94)	47
MB-2	2.0-3.0	8.3	1,009 (179)	54
MB-3	2.0-3.0	8.5	300 (142)	33
MB-4	2.5-4.0	8.6	130 (67)	33
MB-5	2.5-4.0	10.2	400 (214)	43
MB-6	2.0-3.0	9.9	506 (234)	37

* Corresponds to sites identified in Fig. 1.
** Depth sampled.
† Water temperature (° C) on bottom.
‡ Mean number of walleye eggs collected for all tows at each site (standard deviation).
§ Percent of eggs alive at time examined.

2,582 per 2-min tow and averaged 939 (±419) eggs per tow (Roseman 2000; Roseman and others 2001). The greater number of eggs collected from reefs may indicate that more fish spawn on the reefs. Additionally, the reefs may provide better incubation substrate than the mounds in Maumee Bay. The surfaces of the reefs have numerous crevices and cavities as well as a varied substrate composition ranging from silt to boulders and exposed bedrock (Herdendorf and Braidech 1972; Roseman and others 1996), whereas the mounds in Maumee Bay appeared to be mainly composed of sand. Substrate composition at the Turtle Island site was harder and coarser than near the river channel and more similar to that on mid-lake reefs (Roseman and others 1996). The coarse substrate particle sizes on the reefs and at Turtle Island may retain eggs better than the sandy substrate on mounds near the river channel and explain why we observed higher egg numbers at the Turtle Island site and on the reefs.

Walleye spawning areas in the Maumee River are located about 70 km upstream from Maumee Bay, with no known spawning areas between the two locations (Trautman 1981; Mion and others 1998). Because walleye eggs are demersal and incubate on and within bottom substrates (McMahon and others 1984), and given the dilution potential due to the enormous volume of river discharge and long transit time from the upstream spawning locations to Maumee Bay (Mion and others 1998), we feel it is highly unlikely that eggs collected during this study originated at upstream spawning locations and indeed represent evidence of discrete spawning groups of walleye in Maumee Bay.

Fish stocks represent unique breeding groups, often possessing novel forms of genetic, physiological, and ecological variation that maintain diversity within a species (Allendorf and others 1987). Therefore, walleye spawning in Maumee Bay could represent an important evolutionary and ecological link in the Lake Erie walleye population different from stocks identified in the Maumee and Sandusky rivers (Stepien and Faber 1998). Further, Maumee Bay provides unique fishing opportunities to anglers compared to other locations in western Lake Erie. Maumee Bay is protected from severe wind events affording small boats access to a large concentration of adult walleye when open waters of the lake may be inaccessible. Because Maumee Bay spawning sites are protected from severe storm events that can reduce egg and larval survival in rivers (Mion and others 1998) and on mid-lake reefs (Roseman and others 2001), reproductive success of walleye spawned in the bay may be higher resulting in a major contribution to the developing year-class in some years. This recruitment potential offered by spawning habitat in Maumee Bay adds additional resilience to the Lake Erie population.

Although anecdotal evidence suggested that walleye spawned in Maumee Bay in the early part of the 20th century when habitat conditions were more pristine, no direct evidence was ever collected to substantiate these claims. Reports describing habitat quality during the early part of the century indicated Maumee Bay certainly had adequate gravel substrates and water quality (high dissolved oxygen, low turbidity) to support successful walleye spawning (Wakeham and Rathbun 1897; Pinsak and Meyer 1976). However, habitat conditions in Maumee Bay were noticeably deteriorated by 1930 (Wright 1955) and became severely degraded between 1950 and 1970, coinciding with the decline in abundance of walleye in Lake Erie (Schneider and Leach 1977; Hatch and others 1987). Walleye spawning habitat in the lake and tributaries were greatly degraded during this time period due to siltation, eutrophication, and associated low dissolved oxygen levels (Schneider and Leach 1977), and any spawning areas in Maumee Bay would also have been vitiated. Beneficial changes in landuse practices in the watershed since the 1970s have led to improvements in water quality and habitat conditions for walleye spawning and nursery areas (Hatch and others 1987; Knight 1997). Large numbers of walleye again spawn in Lake Erie tributaries as well as on mid-lake reefs (Roseman and others 1996; Turner and others 2001), and our evidence of walleye spawning in Maumee Bay is further indication of successful management resulting in improved habitat conditions and the rehabilitation of the Lake Erie walleye population.

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