Final Report: TESTING FLORA AND FAUNA INDICATORS OF COASTAL WETLAND HEALTH IN LAKE ERIE

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BACKGROUND

Degradation of Great Lakes coastal wetlands by anthropogenic factors is ongoing and widespread (Maynard and Wilcox 1998). When the United States and Canada signed the Great Lakes Water Quality Agreement of 1978, they agreed "... to restore and maintain the chemical, physical, and biological integrity of the waters of the Great Lakes Basin Ecosystem." Since then they have prepared Lakewide Management Plans (LaMP) to achieve these goals. The 2000 Lake Erie LaMP emphasized the need to develop procedures to accurately measure aquatic ecosystem integrity to gauge the success of management strategies. Methods are being developed to monitor habitat quality by sampling fish and other vertebrates, macroinvertebrates and plants, and using these data to calculate metrics (e.g., taxa diversity, abundance of indicator taxa or guilds, health of individual organisms) that are correlated with environmental integrity of these habitats. These metrics are used to calculate multimetric Indices of Biotic Integrity (IBI), which are a composite score of several metrics of the sampled community (e.g., Karr and Chu 2000, Thoma 1999, Plafkin et al. 1989, Karr et al. (1986). Hilsenhoff 1987). Often, the IBI score in the site being tested is compared to an IBI at a reference site that has the optimum habitat quality attainable in the region (National Research Council 2000). Different IBI scores at test vs. reference sites indicate that the test site has been affected by pollution or other environmental stressors. Alternately, IBI's can be measured at test sites over time to gauge long-term trends in habitat quality (National Research Council 2000)

Recently, a taskforce assigned to identify methods to monitor ecosystem integrity in the Great Lakes recommended developing IBI's for coastal wetlands to reveal both episodic disturbance and long-term trends of habitat quality (Bertram and Stadler-Salt 2000). However, there are several difficulties in developing an IBI for coastal wetlands. First, each of the Great Lakes has distinctly different physico-chemical conditions (Maynard and Wilcox 1998). For example, Lake Erie is the most shallow and productive of the Great Lakes, and it is particularly susceptible to effects of seiches and storm action. This indicates that biotic communities in coastal wetlands will be different in each of the Great Lakes, which may affect the choice of metrics to include in an IBI. Second, several types of coastal wetlands are found in the Great Lakes basin, and these differ in hydrogeomorphic conditions (Keough et al. 1999). Although all Great Lake coastal wetlands are affected by water level changes and chemical inputs from the lake, they vary by

their connectedness to the Great Lakes and whether they receive river inputs (Keough et al. 1999). Therefore, any IBI's used in coastal wetlands may have to be calibrated by wetland type.

Currently, there is interest in developing IBI's using aquatic invertebrates, fish and plants in wetlands. Invertebrates are useful because: 1. they are sensitive to environmental stressors, 2. they have a short life-span and therefore communities will respond rapidly to changes in habitat conditions, and 3. their life-histories are often well understood (Innis et al. 2000). Furthermore, sampling flying adult aquatic insect can be also used to monitor the establishment of functions in constructed wetlands (King and Brazner 1999, Garono and Kooser 1994). We propose to build on previous studies that developed preliminary IBI's (Kashian and Burton 2000, Burton et al. 1999) in Lake Huron coastal wetlands. These papers found that species richness, species diversity, and relative abundance of invertebrates were useful metrics. Aquatic invertebrates are abundant in Lake Erie coastal wetlands (de Szalay and Cassidy 2001), and these metrics should be useful in our wetlands.

Fish assemblages are also sensitive to environmental conditions, making them quite amenable to use in assessments of system integrity (Karr 1981). Given the importance of coastal wetlands as spawning, nursery, and foraging areas, fish should be sensitive to differences in habitat quality among coastal wetlands. Previous research has demonstrated the importance of turbidity and macrophyte cover and diversity as critical variables for characterizing fish assemblages, likely due to the role these variables play in determining fish recruitment along trophic gradients (Brazner 1997, Brazner and Beals 1997). In an IBI developed for Lake Erie drowned river mouths (i.e., lacustuaries), Thoma (1999) included a broad range of diversity and abundance metrics including species richness, # sunfish species, # cyprinid species, % phytophilic individuals, % non-indigenous species, % DELTs.

For the purposes of vegetation IBI development, the goal is to correlate a wetland's aggregate vegetation characteristics to measures of wetland disturbance and quality. Major concerns in selecting a sampling method are ease of use, cost, reproducibility of results, and the ability to obtain a complete list of plant species. This last concern is related to Ohio's use of a Floristic Quality Assessment Index (FQAI) (Andreas and Lichvar 1995) that requires a relatively

complete flora of a site. In coastal marshes, a narrow shrub zone typically gives way to a broad emergent zone which grades into a floating-leaved marsh to open water zone. This spatial heterogeneity must also be taken into account by the sampling design. Although some methods are being tested in inland wetlands, (e.g., Mack 2001, Andreas and Lichvar 1995) no methods have been widely adopted in Great Lake coastal marshes.

The goal of this project was to compare the applicability of different sampling methods that can be used to provide data for four proposed SOLEC coastal wetland indicators outlined in Bertram and Stadler Salt (2000): #4501 (invertebrate community health); #4502 and #4503 (fish community health and deformities, eroded fins, lesions, and tumors [DELTS]); and #4513 (plant community health). These data will be useful to 1) select metrics that are correlated with habitat quality, 2) establish baseline conditions existing in these wetlands to allow managers to measure long-term changes in response to management strategies, and 3) show how metrics are affected by habitat types. We tested how well different sampling methods detected biotic differences between two types of coastal wetlands in Lake Erie: 1) protected embayment wetlands that are largely protected from wave action in the lake by a partial barrier beach or dike across the mouth of the wetland, and 2) open lacustrine wetlands that lack the protective barrier beach and are largely exposed to wave action. Our project was coordinated with projects conducted at other Great Lake sites to show how metrics should be calibrated across different lakes.

We examined two assumptions that are important to developing IBIs. First, we tested the *a priori* assumption that habitats with different physical characteristics would have different biotas. For example, poor quality wetlands should have lower plant biodiversity or abundance than good quality wetlands. Further, open lacustrine wetlands exposed to high wave action might support lower plant diversity than protected embayment wetlands that are sheltered from waves. We chose to compare open lacustrine and protected embayment wetlands because we did not expect to find enough pristine reference sites to compare good and poor quality wetlands. Second, we tested the *a priori* assumption that taxa groups should show similar responses to physical characteristics in each wetland. For example, good quality wetlands that supported a high plant biodiversity would also have a high fish biodiversity. If this was not true than it may not be valid to sample one taxa group (e.g. plant communities) to determine the overall habitat quality.

METHODS

Habitat Selection and Abiotic Sampling Methods

At a preliminary coordination meeting all grantees agreed on a definition of the two habitat types that were included in our projects. We sampled open lacustrine wetlands, defined as those that are either a shallow sloping beach, open shoreline, large bays, or open (unrestricted) embayment. These all are open to wave action and storm surge activity from the lake. We also sampled protected embayment wetlands, defined as those that either are a protected embayment, sandspit embayment, or are a barrier beach wetland. Although a barrier isolates wetlands from wave energy, the wetlands were not hydrologically isolated from Great Lakes. No wetlands received inputs from streams of more than 3rd order.

Our grant funded our us to sample 6 wetlands. However, with the amount of natural variability in coastal wetlands, it would been difficult detect differences among habitats with this low of a sample size. Therefore, 2 additional wetlands were added to our sample size. We visited 13 potential sample sites in summer 2002 and randomly selected 8 sites. Table 1 lists the 4 open lacustrine wetlands and 4 protected embayments (8 wetlands total) we sampled for this study. Although some protected embayments had a rip-rapped dike, all were permanently open to the lake (i.e., their water levels are controlled by water level changes in Lake Erie). All sites are located in western Lake Erie in Ohio and Michigan, USA because this area has almost all open lacustrine and protected embayment wetlands along the United States border of Lake Erie (Maynard and Wilcox 1997).

Table 1. Coastal marshes in Lake Erie that are included in this survey. Four open lacustrine and four protected embayment wetlands were randomly chosen and sampled in summer 2002.

Type	Name, Location	Ownership
Open Lacustrine		
	Potters Pond at Cedar Point Unit of Ottawa NWR (Oak Harbor, Lucas Co., OH)	USFWS
	Pointe Mouille State Game Area (Detroit, Monroe Co., MI)	Michigan DNR

	Erie State Game Area, (Monroe, Monroe Co., MI)	Michigan DNR
	Lake Erie Metropark (Monroe, Monroe Co., MI)	Huron Metroparks
Protected Embayment		
	Sheldon's Marsh State Nature Preserve (Huron, Erie Co., OH)	Ohio DNR
	Willow Point Marsh WA (Fremont, Erie Co., OH)	ODNR
	Metzger Marsh WA (Oak Harbor, Lucas Co., OH)	USFWS, ODNR
	Young Marsh at Darby Unit of Ottawa NWR (Oak Harbor, Ottawa Co., OH)	USFWS

In June 2002, we visited each wetland to identify sampling locations and estimate the relative amount of environmental degradation. We returned to all wetlands from 15 to 21 August 2002 to sample invertebrates, fish, and plants (see details below). We chose this period because this is the period of the greatest invertebrate biomass and diversity and before most plants begin to senesce (Burton et al. 1999, Fennessy et al. 1998, F. de Szalay, unpubl. data). Our field crew sampled wetlands sequentially as we travel along the coastline, and it took 12-24 hours with travel time to complete all duties at each wetland. We collected positional information at all sampling locations with GPS units (Trimble Geoexplorer 3) (Table 2).

Table 2. Sampling locations at coastal wetlands included in this study.

Young Marsh at Ottawa NWR (YM)			**Sheldon's Marsh Nature Preserve (SM)**		
Sampling Locations	**Lat**	**Long**	**Sampling Locations**	**Lat**	**Long**
Fyke nets 1	41deg 32' 19.21"N	83deg 00'19.57"W	Fyke nets 1	41deg 25' 15.14"N	82deg 36'73.01"W
Fyke nets 2	41deg 32' 20.31"N	83deg 00'21.83"W	Fyke nets 2	41deg 25' 18.55"N	82deg 36'42.55"W
Minnow trap 1	41deg 32' 19.02"N	83deg 00'19.93"W	Minnow trap 1	41deg 25' 14.64"N	82deg 36'34.01"W
Minnow trap 2	41deg 32' 19.93"N	83deg 00'19.23"W	Minnow trap 2	41deg 25' 17.79"N	82deg 36'40.43"W
Minnow trap 3	41deg 32' 20.08"N	83deg 00'22.62"W	Minnow trap 3	41deg 25' 19.34"N	82deg 36'43.25"W
Activity trap 1	41deg 32' 19.99"N	83deg 00'21.60"W	Activity trap 1	41deg 25' 15.62"N	82deg 36'35.59"W
Activity Trap 2	41deg 32' 23.21"N	83deg 00'22.28"W	Activity Trap 2	41deg 25' 16.39"N	82deg 36'38.97"W
Plant transect	41deg 32' 20.42"N	83deg 00'20.54"W	Plant transect	41deg 25' 17.60"N	82deg 36'43.56"W
Willow Point Wildlife Area (WP)			**Point Mouillee State Game Area (PMSGA)**		
Sampling Locations	**Lat**	**Long**	**Sampling Locations**	**Lat**	**Long**
Fyke nets 1	41deg 26' 14.07"N	82deg 52'55.03"W	Fyke nets 1	41deg 59' 39.95"N	83deg 13'36.61"W

Fyke nets 2	41deg 26' 13.44"N	82deg 52'58.56"W	Fyke nets 2	41deg 59' 42.24"N	83deg 13'33.94"W
Minnow trap 1	41deg 26' 12.12"N	82deg 52'51.05"W	Minnow trap 1	41deg 59' 43.00"N	83deg 13'34.85"W
Minnow trap 2	41deg 26' 13.51"N	82deg 52'49.92"W	Minnow trap 2	41deg 59' 41.59"N	83deg 13'35.45"W
Minnow trap 3	41deg 26' 14.48"N	82deg 52'54.02"W	Minnow trap 3	41deg 59' 40.75"N	83deg 13'35.83"W
Activity trap 1	41deg 26' 13.65"N	82deg 52'47.94"W	Activity trap 1	41deg 59' 41.65"N	83deg 13'34.76"W
Activity Trap 2	41deg 26' 13.42"N	82deg 52'48.63"W	Activity Trap 2	41deg 59' 41.65"N	83deg 13'34.76"W
Plant transect	41deg 26' 12.17"N	82deg 52'54.67"W	Plant transect	41deg 59' 45.17"N	83deg 13'27.24"W

Potter's Pond at Ottawa NWR (PP)

Sampling Locations	**Lat**	**Long**
Fyke nets 1	41deg 40' 44.08"N	83deg 18'28.16"W
Fyke nets 2	41deg 40' 44.16"N	83deg 18'26.89"W
Minnow trap 1	41deg 40' 47.23"N	83deg 18'30.59"W
Minnow trap 2	41deg 40' 45.27"N	83deg 18'28.66"W
Minnow trap 3	41deg 40' 45.39"N	83deg 18'27.76"W
Activity trap 1	41deg 40' 46.80"N	83deg 18'30.64"W
Activity Trap 2	41deg 40' 46.80"N	83deg 18'30.64"W
Plant transect	41deg 40' 45.71"N	83deg 18'32.59"W

Lake Erie Metro-Park (LEM)

Sampling Locations	**Lat**	**Long**
Fyke nets 1	42deg 04' 16.22"N	83deg 11'34.41"W
Fyke nets 2	42deg 04' 14.02"N	83deg 11'33.11"W
Minnow trap 1	42deg 04' 16.99"N	83deg 11'35.10"W
Minnow trap 2	42deg 04' 16.82"N	83deg 11'34.29"W
Minnow trap 3	42deg 04' 11.11"N	83deg 11'31.98"W
Activity trap 1	42deg 04' 10.43"N	83deg 11'30.95"W
Activity Trap 2	42deg 04' 10.43"N	83deg 11'30.95"W
Plant transect	42deg 04' 12.54"N	83deg 11'32.02"W

Erie State Game Area (ESGA)

Sampling Locations	**Lat**	**Long**
Fyke nets 1	41deg 44' 47.13"N	83deg 28'21.07"W
Fyke nets 2	41deg 44' 47.36"N	83deg 28'16.61"W
Minnow trap 1	41deg 44' 46.36"N	83deg 28'21.71"W
Minnow trap 2	41deg 44' 46.59"N	83deg 28'19.25"W
Minnow trap 3	41deg 44' 47.29"N	83deg 28'18.61"W
Activity trap 1	41deg 44' 46.96"N	83deg 28'19.03"W
Activity Trap 2	41deg 44' 46.47"N	83deg 28'18.52"W
Plant transect	41deg 44' 47.03"N	83deg 28'13.89"W

Metzger Marsh Wildlife Area (MM)

Sampling Locations	**Lat**	**Long**
Fyke nets 1	41deg 38' 17.77"N	83deg 13'18.05"W
Fyke nets 2	41deg 38' 18.07"N	83deg 13'22.88"W
Minnow trap 1	41deg 38' 16.49"N	83deg 13'19.39"W
Minnow trap 2	41deg 38' 17.24"N	83deg 13'23.10"W
Minnow trap 3	41deg 38' 17.50"N	83deg 13'23.79"W
Activity trap 1	41deg 38' 18.36"N	83deg 13'24.87"W
Activity Trap 2	41deg 38' 17.93"N	83deg 13'25.07"W
Plant transect	41deg 38' 18.86"N	83deg 13'25.44"W

We sampled physical characteristics in each wetland by measuring abiotic conditions with field meters (Y.S.I. Model 85 D.O./Conductivity/Temperature meter, Hach pH and turbidity meters). We also collected water samples at each wetland in each of two representative locations, immediately preceding invertebrate sampling. Each sample was collected from the midpoint of

the water column in a 1-L prewashed, acid-rinsed polyethylene bottle without disturbing the bottom sediments or any adjacent vegetation. The samples were placed on ice for delivery to the Heidelberg's WQL as soon as practical, but in all cases within one week. Each sample was analyzed by automated methods (USEPA 1979) for parameters including total suspended solids, soluble reactive phosphorus, total phosphorus, nitrate, nitrite, ammonia, total Kjeldahl nitrogen, chloride, sulfate, soluble reactive silica, and specific conductance. These data were used to determine water quality in each wetland.

To describe landscape measures and extent of each wetland, we used high resolution aerial photographs of all wetlands from online USGS databases (http://terraserver.homeadvisor.msn.com). We also these images, information observed during our site visits, and used Landsat 7 imagery for the western Lake Erie region to identify current land use adjacent to the sample sites (urban, agricultural land cover) and other factors that affect habitat quality in the wetlands (e.g., proximity to navigable channels and recreational boating, and dredged canals in the wetland). These data were used to characterize the relative potential that the habitat has been disturbed.

Biotic Sampling Methods

SOLEC Indicator #4501 (Invertebrate Community Health)

We used four methods to sample wetland invertebrate populations. For two sampling methods we collected invertebrates with D-frame sweep nets (500 micron mesh) to collect invertebrates in flooded vegetation using methods described in Burton et al. (1999). Macroinvertebrates were sampled in all wetlands in the emergent plant zone, which was always dominated by either *Typha angustifolia* or *Phragmites australis*. Macroinvertebrates were also sampled in open water zone in each wetland, which was either unvegetated or had a mix of submersed macrophytes. Each sweep net sample consisted of four 1-m long sweeps collected at random locations in the emergent plant zone or the open water zone. Two replicate sweep net samples were collected in each zone (i.e., 2 open water and 2 emergent plant samples in each wetland). For the first sampling method, we preserved a sample from each zone in 95% ethanol, brought them back to the laboratory, and sorted them under the microscope (henceforth these will be called the lab-sorted sweep samples). For the second sampling method, we immediately placed

the samples in a gridded white enamel pan filled with filtered water and picked out the live invertebrates (henceforth these will be termed the live-sorted sweep samples). Invertebrates were collected by picking all specimens from one randomly determined area of the grid before moving on to the next grid area. Samples were sorted for one-half -person-hour or until 150 invertebrates were collected, whichever came first. Special consideration was made to detect small/cryptic organisms, but it was probably impossible to avoid some bias towards large and active individuals with this method.

A third method was used activity traps to collect nektonic invertebrates. Activity traps were modified from Murkin et al. (1983). Traps were constructed from 1-L plastic bottles with a funnel (small opening: 2 cm; large opening: 11 cm) attached in a hole cut in the bottle lid and a second funnel attached in a hole cut in the bottom of the bottle. In each site, we used six traps attached to wooden stakes at random locations in the emergent plant zone and six traps in the open water zone. Traps remained in place for 24 hours, and trapped invertebrates were collected in a 250 micron screen and preserved in the field with ethanol.

A fourth method was sampling adult caddisflies (Insecta: Trichoptera) with ultraviolet light traps for one night at each wetland. Four light traps were deployed at each wetland and run throughout the night. All traps were set near areas where aquatic sweep netting was performed, but within the vegetation stand. Traps were positioned approximately 20 m from each other within the emergent vegetation to keep individual traps independent. Traps comprised a 5-gallon bucket staked into the marsh sediment with a BioQuip 4-watt battery powered UV light suspended within. The bucket was filled with approximately 6 cm of water to which several drops of liquid detergent were added. When switched on at dusk, insects flying over the bucket (and thus only species associated with the habitat being sampled and not drawn in from a long distance or nearby aquatic habitats) were be attracted to the light (Armitage 2000). When insects flew into the bucket, they landed on the soapy water and fell through the surface film and drowned. Specimens were collected the following morning by sieving the bucket contents and preserving insects in 95% ethanol.

Invertebrates were in all samples were identified to lowest possible taxon and enumerated in the laboratory. Invertebrates in sweep net and activity trap samples included mostly larval insects, and therefore, were identified to family or genus. Invertebrates in light traps were all adult insects and could be identified to species by dissecting out the male genitalia. Trichopteran keys in Merritt and Cummins (1996), Ross (1944), Blickle (1979), and Armitage and Hamilton (1986) were referred to, as well as previously identified specimens in the collections of the Cleveland Museum of Natural History.

SOLEC Indicators #4502 and #4503 (fish community health and DELTS)

We used two methods to sample wetland fish assemblages. First, we used two sets of paired fyke nets (fine mesh trap: 3/16"mesh; coarse mesh trap: 1/2" mesh) that were fished overnight in tandem and set perpendicular to the shoreline (with 50' lead and 10' wing nets). Paired nets were set in shallow open water near the emergent plant zone at each sampling site. Second, we used minnow traps to supplement fyke net sampling. Three unbaited minnow traps were placed at each of three shallow open water areas (9 traps total) near the fyke nets. All traps were left in the wetland overnight and collected at the same time the next day. All fish that are captured were identified, counted, measured and weighed, and most fish were immediately released live. Fish that could not be identified in the field were brought back to the lab and keyed to species, and voucher specimens were kept. All captured fishes were also inspected for externally observable deformities, eroded fins, lesions, and tumors (DELTS).

SOLEC Indicator #4513 (plant community health)

We adopted the plant sampling methods used by the Ohio EPA (Mack 2001). For a vegetation IBI development, it is important to include the presence and percent cover of the species in the shrub and floating-leaved zones, but the main focus should be on the emergent zone (Mack 2001). Therefore, we locate sampling plots within the emergent zone but the "tails" of the plot include portions of the shrub and aquatic bed zones. The sampling plots were located within an area that was judged to be " representative" of the entire wetland based on a visual survey conducted when we scouted the wetland.

A sampling plot usually consisting of a 2x5 array of 10 m x 10 m modules, i.e. 20 m wide by 50m long (= 0.1 ha), within the jurisdictional boundary of the wetland. We modified the shape of this plot to reach from the shrub zone to the aquatic bed zone when the emergent plant zone was very broad (e.g., in some cases plot consisted of a 1 X 10 array or other sized modules). Once the plot is laid out, all species within the plot were identified and cover is estimated at the 0.1 hectare scale. Four randomly chosen modules were termed the "intensive modules" and species cover class values were recorded for each module separately.

We also sampled plant depth of occurrence in nested quadrats of $0.01m^2$, $0.1m^2$, $1m^2$, $10m^2$ located in two opposite corners of the four intensive modules. Depth of occurrence was defined as the size of the quadrat in which the presence of a species is first noted. Starting in the first corner of the module, all species in a 0.32 x 0.32 m ($0.1m^2$) subquadrat were listed and assigned a value of 4. Next a 1.0 x 1.0 m ($1.0\ m^2$) subquadrat was surveyed and each new species encountered was assigned a value of 3, followed by a 3.16 x 3.16 m ($10m^2$) subquadrat with new species assigned values of 2. All species within the module that were not encountered in the $10m^2$ nested subquadrats received a value of 1. The survey for depth of occurrence was then repeated in four nested quadrats in the second corner of the module.

Plants were identified in the field to species where possible. We collected voucher specimens for lab verification of species identification, especially the more taxonomically difficult genera and any unidentified specimens. Vouchers are retained in the Kent State University herbarium.

We also kept notes on the amount of time spent using each invertebrate, fish, and plant sampling method in the field and the time spent processing samples in the laboratory. These observations were used to compare the relative benefit vs. cost of the different methods.

Statistical Analyses

We analyze the data in three ways. First, we tested the *a priori* assumption that differences in the physical characteristics in Open Lacustrine wetlands and Protected Embayment wetlands caused differences in their flora and fauna. For this, we used t-tests to compare total numbers and richness between open and protected wetlands with each sampling

technique (e.g., fish sampled with fyke nets and minnow traps, invertebrates collected with lab-sorted sweep net samples, live-sorted sweep net samples, activity traps, and light traps, and plants sampled with transects). We also examined the data for light trap catches by species because we had abundant numbers of many caddisfly species. *Oecetis* sp. males were compared separately, and all *Oecetis* spp., including females, were lumped for compared. All *Hydroptila* were lumped for comparison because a large proportion were undetermined females. Taxa that were only collected in one wetland type (i.e., either protected or open, but not both) were not compared statistically. Also, *Hydropsyche* spp. and *Ochrotrichia tarsalis* were not compared because their larval habitat is strictly lentic, and therefore the specimens collected are incidentals.

Second, we tested the *a priori* assumption that taxa groups should show similar responses to physical characteristics in each wetland. For example, high quality wetlands that supported a high plant biodiversity should support a high fish biodiversity. We made pairwise comparisions of richness among all taxa groups (invertebrates, fish and plants) using linear regression analyses. IBI protocols that employ methods that collect abundant and diverse samples are probably more likely to detect differences among habitats than using methods that either collect relatively few organisms or do not collect many different species. Therefore, we also compared the efficiency of the different sampling methods by using ANOVAs to compare taxa richness of fish data from the combined Fyke net and minnow trap collections, invertebrates collected with lab-sorted sweep net samples, live-sorted sweep net samples, activity traps, and light traps, and plants sampled with transects. We used Tukeys tests to make pairwise comparisons among means when we ANOVAs were significant (i.e., $P<0.05$).

RESULTS

Note: the complete data sets are included on the accompanying CD-ROM

Descriptions of Habitat Quality and Water Chemistry

Our description of physical features of these habitats including anthropogenic factors affecting habitat quality is given on Appendix A. All of these sites were disturbed to some extent by

anthropogenic factors. For example, all were considered to be in areas of high public use activities including included fishing, boating, hunting, and sunbathing in or adjacent to the wetland. Observed landscape alterations were mostly mowing and shrub removal related to wildlife habitat management. There were substantial constructed structures in many wetlands including dredged boat channels, boat ramps and docks, roads and parking lots, and nearby residential or industrial buildings. All had some portion of the shoreline armored by rip-rap, and three sites (Potters Pond, Willow Point, and Metzgers Marsh) had the majority of their shoreline rip-raped. Of the 4 protected embayment wetlands, only Sheldon's Marsh had a naturally deposited sand barrier beach that was not capped by rip-rap. Metzgers Marsh and Willow Point were surrounded by a dike that had a narrow opening, and Young Marsh opened to Lake Erie via a dredged boat channel. Therefore, the hydrological connection with the lake was somewhat constricted in the latter three protected embayment wetlands. Most other hydrological alterations in all wetlands were relatively minor, and these consisted of ditches draining into the wetland.

We sampled water chemistry in all wetlands and the data is presented in Appendices B, C. Based on water chemistry, Point Mouillee was markedly different from the other habitats. It had much higher levels of conductivity, Ca, Cl, Mg and Sr. A ditch that received effluents from a nearby gravel quarry drained into Point Mouillee near our sampling location, and this was probably the reason for these measurements. We collected water samples inside this ditch, and found that measurements of these parameters were about twice the levels we found at our sampling location (data not shown). Turbidity also ranged widely between sites with Willow Point and Erie State Game Area having the most turbid water. Turbidity was usually higher on windy days than calm days due to wave action that churned up the sediments in these shallow soft-bottomed wetlands.

Descriptions of Biota

1. Plants

108 species of emergent plants were collected at all wetlands, including 13 submergent species (Appendix D). The average taxa richness at all wetlands was 34 species, and richness ranged from 23 to 41 species per wetland. Submergent plant richness ranged from 1 to 8 per site.

Examining the plant taxa lists did not show a pattern that either submergent or emergent plant communities were different between open lacustrine or protected embayment wetlands. Although plant diversity was high in most wetlands, invasive plants were abundant in most wetlands. For example, emergent plant communities were generally dominated by either *Typha angustifolia* and *T. glauca* or *Phragmites australis* that are not native in Lake Erie coastal wetlands.

2. Fish

27 species of fish were captured at all locations (Appendix E). Species richness at individual sites ranged from 10 to 16 species, and number of fish trapped per site ranged from 80 to 1083 fish per site. Two state endangered banded killifish were captured; one fish at each of Potters Pond and Lake Erie Metropark. Fish with DELTS were observed at 6 of the 8 wetlands (Sheldon's Marsh, Willow Point, Young Marsh, Metzgers Marsh, Erie State Game Area, Lake Erie Metropark).

3. Invertebrates

Activity traps collected a total of 77 invertebrate species in all wetlands; mean species richness ranged from 11 to 20 species per wetland, and abundance ranged from 119 to 518 invertebrates per wetland (Appendix F). Most activity traps were recovered, but samples were sometimes lost during storms or when low water seiches exposed the traps above the waterline.

Sweep samples that were live-sorted in the field collected a total of 70 invertebrate species in all wetlands; species richness ranged from 12 to 30 species per wetland, and abundance ranged from 84 to 1032 invertebrates per wetland (Appendix G). Sweep samples that were sorted in the laboratory collected a total of 56 invertebrate species in all wetlands; species richness ranged from 14 to 33 species per wetland, and abundance ranged from 531 to 7906 invertebrates per wetland (Appendix H). Insect families that were very abundant in these samples were midges (Chironomidae), waterboatmen (Corixidae), damselflies (Coenagrionidae), and mayflies

(Caenidae). Other common invertebrates were snails (Physidae and Planorbidae), worms (Oligochaeta), scuds (Gammaridae, Talitridae).

Light traps collected a total of 15 caddisfly taxa in all wetlands; species richness ranged from 7 to 12 taxa per wetland, and abundance ranged from 116 to 601 invertebrates per wetland (Appendix I). Most traps were successfully retrieved, but in some areas seiches swamped some of the traps (Sheldons Marsh, Willow Point, and Point Mouillee each lost 1 trap, Potter's Pond lost 2 traps, and Young Marsh lost all 4 traps). The most numerous and species-rich group was the microcaddisfly family Hydroptilidae. Leptoceridae (long-horned caddisflies) were the next most numerous and species-rich, and Polycentropodidae and Hydropsychidae were taken only in small numbers. Two state records were obtained during trapping (*Ochrotrichia tarsalis* for Michigan, *Oxyethira verna* for Ohio). Representatives of all species from each site are currently vouchered in the Invertebrate Zoology collection of the Cleveland Museum of Natural History.

Testing of Sampling Methods

1. Comparison of Richness and Abundance Among Sampling methods

We compared taxa richness collected by all sampling techniques. Mean taxa richness among the different methods ranged from as low as 9 caddisfly species per light trap sample to as high as 34 plant species per transect (Table 3). Mean invertebrate taxa richness collected with sweep nets were also relatively high (23-25 taxa per sample).

Table 3. Mean taxa richness collected by all sampling techniques in all wetlands. Light trap data from Young Marsh is not available because the traps were lost in a storm

	Invertebrate Data				Fish Data	Plant Data
Site	**Activity traps**	**Live - sorted sweeps**	**Lab - sorted Sweeps**	**Light traps**	**Fyke + Minnow trap combined**	**Transect**
PMSGA	16	30	30	11	15	29
ESGA	11	19	22	8	10	35
LEM	14	23	33	8	16	39
PP	20	26	26	7	11	31

SM	16	12	14	10	12	36
WP	17	22	21	7	13	41
MM	17	26	26	12	15	38
YM	20	26	27	N/A	10	23
Mean	16.4	23.0	24.95	9.0	12.8	33.9
SE	1.1	2.0	2.1	0.8	0.8	2.1

Mean taxa richness was different among sampling techniques ($F_{5,41}$= 31.7, P<0.0001). Plant transects had higher taxa richness than all other techniques (Table 4). Invertebrate richness collected with both sweep net methods (lab-sorted samples or live-sorted samples) were higher than all other techniques except plant transects. However there was no difference between invertebrate richness in live-sorted and lab-sorted samples. Fish richness collected with fyke nets and minnow traps was not different from invertebrate richness collected with either activity traps or light traps.

Table 4. Pairwise differences of taxa richness collected by each sampling technique. Values with an * are significantly different (One way ANOVA followed by Tukeys tests).

	Activity trap	**Live-sorted sweeps**	**Lab-sorted sweeps**	**Light trap**	**Fyke and minnow trap**
Live-sorted sweeps	-6.6*				
Lab-sorted sweeps	-8.5*	-1.9			
Light trap	7.4*	14.0*	15.9*		
Fyke and Minnow trap	3.6	10.3*	12.1*	-3.8	
Plant transect	-17.5*	-10.9*	-9.0*	-24.9*	-21.1*

We also compared abundance of invertebrates collected with the four sampling methods (Table 5). Lab-sorted sweep samples collected an average of almost 4,000 invertebrate in each wetland. The other techniques each collected several hundred invertebrates per sample.

Table 5. Mean abundance collected by invertebrate sampling techniques in all wetlands.

	Activity traps	**Live-sorted sweeps**	**Lab-sorted Sweeps**	**Light traps**
PMSGA	119	540	2778	601
ESGA	518	1032	7906	277

LEM	216	482	6424	116
PP	472	943	4596	351
SM	3131	84	531	407
WP	216	468	2122	130
MM	446	675	5746	240
YM	454	324	1368	N/A
MEAN	696.5	568.5	3933.9	303.1
SE	351.7	110.1	930.5	63.9

Mean abundance was significantly different among these methods ($F_{3,27} = 11.08$, $P<0.0001$). Lab-sorted sweep samples collected the highest number invertebrates of all methods (Table 6). There were no other differences among the other sampling techniques.

Table 6. Pairwise comparison of abundance collected by invertebrate sampling techniques. Values with an * are significantly different (One way ANOVA followed by Tukeys test).

	Activity Trap	**Live-sorted sweeps**	**Lab-sorted Sweeps**
Live-sorted sweeps	128.0		
Lab-sorted Sweeps	-3237.4 *	-3365.4 *	
Light trap	393.4	265.4	3630.7 *

2. Correlation among Fish, Invertebrate and Plant richness

We also made pairwise linear regression analyses to check if richness among taxa groups (invertebrates, fish and plants) were correlated among wetlands. Table 7 shows the probability values of the linear regression of each pairwise comparison between taxa. Invertebrate richness in live-sorted sweep samples was positively correlated with lab-sorted sweep samples ($R^2 = 0.66$). No other comparisons were significant.

Table 7. Correlations between sampling techniques. Values are P values of linear regressions between pairwise comparisons of mean richness collected with each sampling techniques. Values with a * are significant ($P<0.05$).

Activity trap	**Live-sorted sweeps**	**Lab-sorted sweeps**	**Light trap**	**Fyke and minnow trap**

Live-sorted sweeps	0.326				
Lab-sorted sweeps	0.872	0.015 *			
Light trap	0.999	0.713	0.932		
Fyke and minnow trap	0.693	0.463	0.218	0.278	
Plant transect	0.226	0.296	0.566	0.678	0.236

3. Comparison among Open Lacustrine and Protected Embayment Wetlands

We compared taxa richness and abundance between open lacustrine and protected embayment wetlands. Fish abundance from the combined catch of fyke nets and minnow traps was higher ($P<0.04$) in protected embayment wetlands than in open lacustrine wetlands (Table 8). No other comparisons between these habitats was significant for any other sampling method.

Table 8. Mean (SE) abundance and richness between open lacustrine and protected embayment wetlands for all sampling methods. **P=** indicates significance of T-tests.

Sampling Method	**Abundance**					**Richness**				
	Open lacustrine		**Protected embayment**			**Open lacustrine**		**Protected embayment**		
	Mean	**(SE)**	**Mean**	**(SE)**	**P=**	**Mean**	**(SE)**	**Mean**	**(SE)**	**P=**
Plant transects	N/A	N/A	N/A	N/A	**N/A**	33.25	(2.3)	34.5	(4.0)	**0.835**
Fyke nets	206.8	(66.0)	641.3	(148.2)	**0.055**	12.8	(1.4)	11.8	(1.0)	**0.582**
Minnow traps	26.0	(18.4)	80.0	(21.0)	**0.101**	3.5	(0.5)	5.8	(0.9)	**0.072**
Fyke nets and minnow traps	232.8	(82.8)	721.3	(153.9)	**0.038**	13.0	(1.5)	12.5	(1.0)	**0.793**
Activity traps	331.3	(97.0)	1061.8	(692.0)	**0.373**	15.3	(1.9)	17.5	(0.9)	**0.340**
Live-sorted sweeps	749.3	(139.3)	387.8	(124.3)	**0.101**	24.5	(2.3)	21.5	(3.3)	**0.491**
Lab-sorted	5426.0	(1112.3)	2441.8	(1148.3)	**0.111**	27.8	(2.4)	22.0	(3.0)	**0.183**

sweeps									
Light traps	336.3	(101.0)	259.0	(69.7)	**0.576**	8.5	(0.9)	9.7 (1.3)	**0.540**

When we examined numbers of each caddisfly taxa captured in light traps in these two habitats (Table 9), no taxa were significantly different between open lacustrine or protected embayment wetlands. However, a general trend was that more *Oecetis immobilis* (Leptoceridae) were taken from open (158) vs. protected (8) wetlands (NS, t = -2.10, df = 5, *P* = 0.08). Also, more *Oecetis* spp., *Hydroptila* spp., and *Oxyethira palida* were collected in open than protected wetlands. The only caddisfly that on average was more abundant in protected than open wetlands was the microcaddisfly *Orthotrichia aegerfasciella*. *Polycentropus cinereus* was taken only in protected wetlands, and *Triaenodes abus, Cyrnellus fraternus, Oxyethira verna,* and *Oxyethira zeronia* were taken only in open wetlands, but all of these taxa were rare (each represented < 1% of all specimens taken during the study).

Table 9. Number of each trichopteran taxon collected during study, and mean (+/- 1 S.E.) number of each taxon collected in protected and open wetlands. No significant differences were found for any taxa between protected and open sites (t-test for unequal variances).

Taxon	**n**	**Protected**	**Open**
Leptoceridae			
Oecetis cinerascens (Hagen)	108	3.42 (1.53)	5.71 (3.45)
O. immobilis (Hagen)	166	0.69 (0.54)	10.48 (3.92)
O. inconspicua (Walker)	235	11.19 (4.35)	13.00 (8.03)
Oecetis spp. (plus females)	595	19.75 (3.77)	32.46 (4.11)
Triaenodes abus Milne	15	1.25 (1.25)	0
Polycentropodidae			
Cyrnellus fraternus (Banks)	10	1.08 (0.96)	0
Polycentropus cinereus (Hagen)	1	0	0.08 (0.08)
Hydropsyche spp.	18	1.56 (1.24)	0.31 (0.24)

- *H.* sp. nr. *slossonae* (Banks) plus undet. females			
Hydroptilidae			
Hydroptila spp.	890	31.83 (24.13)	56.96 (27.52)
- *H. spatulata* (Morton)*, H. waubesiana* Betten, plus undet. females			
Orthotrichia aegerfasciella (Chambers)	110	8.89 (4.84)	1.96 (1.79)
Agraylea multipunctata Curtis	306	11.50 (4.30)	14.25 (7.99)
Oxyethira pallida (Banks)	149	1.03 (0.41)	12.29 (7.88)
O. verna Ross	2	0.17 (0.16)	0
O. zeronia Ross	1	0.08 (0.08)	0
Ochrotrichia tarsalis (Hagen)	25	2.53 (2.40)	0.21 (0.13)
TOTAL	2122		

Time spent on each sampling method

Plant transects

Time to set up the transect in each wetland was about 0.5 hours. Substantial time was required to identify and count plants in the field (~4 hours per transect). It took about 2 hours in the evening to press and mount the voucher specimens from each site. However, the only lab-processing time was spent identifying the voucher specimens and the few specimens that were not identified in the field. This only added ~1 hour per sample.

Fish sampling

Time to set up fyke nets and minnow traps, field-process fish catch, and tear down traps was approximately 8 hours per site. This method requires the site is visited on two consecutive days to set up and tear down the traps. Travel time at the site was more for fish sampling than any other sampling technique because the fyke nets were bulky, and several boat trips were required to move them to the collecting site. However, the only lab processing time was spent identifying the voucher specimens and the few specimens that were not identified in the field. This only added ~1 hour per sample.

Invertebrate Activity Traps

Time to set up activity traps, field process the catch, and remove traps from the site was only 0.5 hours per site. This method requires the site is visited on two consecutive days to set up and tear down the traps. Time to process the samples in the laboratory was about 0.5 hours. Time to identify and enumerate samples was about 3 hours per sample.

Live-sorted Sweep Net Samples

Time to collect the sample and prepare it for processing was only about 0.5 hours. An additional 0.5 was spent collected the invertebrates from the pans. Laboratory time to identify and enumerate the invertebrates was about 2 hours per sample.

Lab-sorted Sweep Net Samples

Time to collect and field process the samples was only about 0.5 hours per sample. Laboratory time took over 10 hours per sample for trained undergraduate laboratory assistants to sort the invertebrates from the detritus. An additional ~3 hours was needed to identify and enumerate the invertebrates collected in the sample. This method required by far more time than any other sampling technique.

Light Traps

Time to set up light traps, field-process specimens, and tear down traps was about 1 hour. This method requires the site is visited on two consecutive days to set up and tear down the trap. In the lab, all specimens were identified by JBK, but an assistant helped to sort Trichoptera from other taxa accumulated in the traps. Sorting one collection required 1-3 hours per trap; most collections took one hour, but at some sites numerous mayfly (Ephemeroptera) specimens were taken making it difficult to remove caddisfly adults. Identification and enumeration required ~1 additional hour per sample, depending on the number of specimens and species.

DISCUSSION

In order to develop an IBI, it is useful to compare metrics that evaluate environmental quality in sites that range from pristine reference sites to sites that are impaired by anthropogenic factors. We surveyed 13 coastal wetlands along the western Lake Erie shoreline to locate potential reference sites. Most Lake Erie coastal wetlands are found along the western basin (Maynard and Wilcox 1997), and several major urban centers (e.g., Toledo OH, Monroe MI, Detroit MI) are found in this region. All Lake Erie coastal wetlands have been disturbed to varying degrees by pollution, invasion by exotic species, diking or other anthropogenic factors, and most habitats are highly impacted (Maynard and Wilcox 1998, Herdendorf 1987). Therefore, it was not surprising that we observed many signs of habitat disturbance in all sites we visited including the eight we sampled in this study. All wetlands were impacted by shoreline armoring, roads, and other human-built structures. In all wetlands, portions of the emergent plant stands were dominated by invasive *Phragmites australis* and *Typha angustifolia*, and exotic carp were common. Furthermore, we found fish with DELTS in six of the eight wetlands. This suggests it may be difficult to locate reference sites when developing an IBI for Lake Erie coastal wetlands because there may be few undisturbed wetlands remaining along the United States shoreline.

Although these coastal wetlands are not pristine, they are still providing valuable ecological functions. Many fish species we collected are important gamefish (e.g., black crappie, channel catfish, largemouth bass, smallmouth bass, bluegill, pumpkinseed, yellow perch), forage fish (spottail shiner, emerald shiner, green sunfish), or are state-listed as endangered (banded killifish). There were many juvenile fish, suggesting that these wetlands are important nursery sites for fish. Moreover, the overall biota was relatively diverse. For example, we collected over 100 plant species among all wetlands. The aquatic invertebrate community was also diverse, even though we did not identify most specimens to species or collect the meiofauna (e.g., protozoans, rotifers, and microcrustaceans). Moreover, of the 15 caddisfly taxa we identified, two had never before been collected in the state. This indicates that coastal wetlands provide unique habitats that probably harbor other rare species.

Water quality was similar at most sites. The only wetland that had very different water chemistry was Point Mouillee SGA that showed the impacts of effluents from ditch draining nearby gravel quarry. We did detect some differences in turbidity among the wetlands, which can have a major impact on the wetland biota (Lougheed et al. 2001, Lougheed and Chow-Fraser 2003). However, turbidity changed within a wetland from day to day, and we observed that turbidity increased on windy days. All sites we sampled were shallow and had fine inorganic sediments, and most wetlands had relatively sparse emergent vegetation. Therefore, wave action would easily churn up the sediments. Long-term measurements of turbidity would give a more accurate account of which wetlands were most affected by this factor.

When we compared the sampling techniques, plant transects and sweep nets collected significantly higher taxa richness than light trapping, activity traps, fyke nets and minnow traps. For example, mean taxa richness in plant transects was over three times higher than in light trap samples. Therefore, plant transects and insect sweep netting should provide adequate taxonomic information to develop multi-metric IBIs. Fish samples were not very taxa rich. However, they provided useful information on the presence of DELTS, which is a direct measurement of the impact of water quality on an organism. We only identified the caddisflies captured in our light traps, and therefore we only captured 9 taxa per wetland. The low taxonomic richness in these samples suggest that light traps may not provide enough useful information for an IBI unless used in combination with other sampling techniques. However, a benefit of light trapping is that the adult insects can be identified to the species level, and this may provide better resolution and sensitivity when monitoring for changes in ecosystem qualities than identifying taxa only to family or genus. In contrast, it was not possible to identify many of the aquatic insect larvae found in the sweep net samples to species because taxonomic keys are not available. Light traps samples did not take much time to collect, and adult caddisflies are easy to sort from other insects in the trap. A limitation of using light traps is that challenging specimens require considerable expertise in Trichoptera taxonomy and/or use of voucher collections such as those available at natural history museums. Another problem with light traps and other stationary traps (minnow traps, fyke nets, invertebrate activity traps) was that they were sometimes disrupted by weather. For example, seiches and waves occasionally washed away traps or stranded them

above the water line, and heavy storms swamped some light traps. Furthermore, these methods required that the investigator return the following day, which increases the cost of travel time.

We also compared the abundance of invertebrates captured with the different sampling techniques. Lab-sorted sweep net samples collected much higher numbers of invertebrates than the three other invertebrate sampling methods. Because we also collected high taxa richness with lab-sorted sweep net samples, IBIs that employ this technique should provide good resolution of habitat quality. However, a major disadvantage of this method was that it was very labor intensive to process these samples. We estimated that it took almost three times longer to process the lab-sorted sweep net samples than the live-sorted sweep net samples, which may limit the use of this method. Live-sorted sweep net samples may provide almost as much information than lab-sorted samples because richness estimated by these two methods were strongly correlated, and there was no difference in total richness. Therefore, the usefulness of using live-sorted sweep net samples should be further explored. A potential problem with live-sorting is that the results were somewhat dependent on the skill of the persons searching the sample because small and cryptic invertebrates were easy to overlook. Therefore, we standardized this sampling method by having the same team collect and sort these samples to eliminate investigator bias.

We used these methods to compare open lacustrine wetlands to protected embayments but found few differences between these habitat types. Of the 7 comparisons we ran on total abundance, only one (fish abundance using fyke net and minnow trap data combined) showed a difference between these habitats. Plant, invertebrate, and fish richness were not different between these habitats. Furthermore, comparisons of abundance of the dominant caddisfly species collected in light traps also did not find any differences. This suggests that metrics developed for open lacustrine wetlands may also apply to protected embayment wetlands. We acknowledge that comparing richness and abundance will only detect large-scale differences between habitats. Further analysis of the data with multivariate statistical techniques may detect other differences between the biota of these habitats.

The richness of plants, fish, and invertebrates in these wetlands were not correlated with each other. This indicates that the different groups are responding differently to the physical characteristics in the wetland (i.e., a wetland with low plant biodiversity may still support high fish biodiversity). If this pattern is generally true, IBIs that only sample one group of species (e.g. plants) may not provide information on the biodiversity of other groups (e.g. fish or invertebrates). Therefore, IBIs based on more than one taxa group may provide a better picture of the overall habitat quality in the wetland.

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APPENDICES

Appendix A.

Anthropogenic disturbances observed at coastal wetlands. Wetlands sites are: PM – Point Mouillee State Game Area; ESGA – Erie State Game Area; LEM – Lake Erie Metropark; PP – Potters Pond at Ottawa National Wildlife Refuge; SM – Sheldon's Marsh Nature Preserve, WP – Willow Point Wildlife Area, MM – Metzgers Marsh Wildlife Area; YM – Young Marsh at Ottawa National Wildlife Refuge

	Site							
	PMSGA	**ESGA**	**LEM**	**PP**	**SM**	**WP**	**MM**	**YM**
Hydrologic Alteration								
dewatering in wetland								
point source inlet								
installed outlet, weir							X	
ditch inlet	X	X		X	X	X	X	
tile inlet								
unnatural connection to other waters				X				X
presence of barriers (dams, waterfalls)								
Landscape Alteration								
Vegetation removal/disturbances:								
tree removal	X	X	X	X	X	X	X	

tree plantations					X			
mowing or grazing	X	X	X	X	X	X	X	
shrub removal	X	X	X	X	X	X	X	
Coarse woody debris removal								
Removal of emergent vegetation							X	
Substrate/soil disturbance:								
presence of livestock hooves								
presence of vehicle use							X	X
presence of grading/bulldozing								
presence of filling								
presence of dredging								X
sediment input (from inflow or erosional)					X		X	
areas of land in high public use	X	X	X	X	X	X	X	X
Constructed Structures								
proximity to navigable channels (m)	10	50	50	1500	1500	None	1600	300
proximity to recreational	10	50	50	10	1500	600	1500	300

boating activity (m)								
proximity to roadways that receive regular (daily) traffic	400	400	250	1500	1600	400	1500	250
# of dwellings	3	0	100	0	100	6	6	12
# of industries	1	1	0	0	0	0	0	0
# of "other" buildings	0	1	1	1	3	0	2	0
# of boat docks	1	1	1	1	1	0	1	1
# of paved parking lots	0	2	0	1	1	1	2	1
# of dirt parking lots	1	0	0	0	0	0	0	0
# of boat launches	1	1	1	1	1	1	1	1
% hardened shoreline	40	15	30	100	15	55	100	20
% eroding shoreline	0	5	0	0	0	0	0	0
% shoreline containing a visible dirt road	0	0	0	95	0	5	50	35
% shoreline containing a visible paved road	15	5	10	5	20	2	30	5

Appendix B.

Water quality data analyzed at Heidelberg College's Water Quality Laboratory. Site names are given in Appendix A

Site	NH3	CL	S04	NO2	NO23	SIO2	SRP	TP	TKN	COND	SS	F	Al	Ba
	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	units	mg/l	mg/l	ppm	ppm
PMSGA	0.035	89.25	0	0	0.095	3.955	0.006	0.023	0.3755	1996	11.55	0.67	0.1636	0.03385
ESGA	0.007	54.05	60.75	0	0	3.895	0.016	0.1595	1.345	579	35.85	0.36	0.7066	0.0444
LEM	0.009	28.55	36.9	0	0.16	1.89	0.026	0.135	0.9405	372.5	72.1	0.305	0.77105	0.0258
PP	0.037	15.7	22.7	0	0	0.955	0.0165	0.0515	0.5625	276.5	7.8	0.175	0.389	0.0181
SM	0.0535	29.1	10.55	0	0.04	9.48	0.203	0.387	1.833	385	27.95	0.245	0.66375	0.01395
WP	0.039	36.45	95.95	0	0	6.185	0.01	0.378	2.2875	542	129	0.37	1.4224	0.04505
MM	0.0255	19.6	10.15	0	0	1.355	0.0135	0.0415	0.7215	330	5.6	0.19	0.34105	0.02215
YM	0.032	22.35	76.4	0	0	5.405	0.012	0.259	1.701	420	117.15	0.36	1.3787	0.1069

Site	Ca	Cd	Cr	Cu	Fe	K	Mg	Mn	Na	Pb	Sr	Zn
	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
PMSGA	276.32	0.00065	0.00275	0.0116	0.2072	3.8327	84.8915	0.0238	29.3405	0.0062	6.35095	0.0028
ESGA	53.453	0.0016	0.0015	0.0188	1.1328	3.61385	16.259	0.08795	25.9265	0.0071	0.96585	0.00765
LEM	46.459	0.0008	0.0029	0.0253	1.43635	2.6322	12.285	0.03995	18.8555	0.00635	0.5692	0.01095
PP	30.2195	0.00105	0.0014	0.0329	0.20705	1.25215	15.4025	0.0195	6.87675	0.01165	0.28695	0.00435
SM	49.6555	0.00155	0.00265	0.03645	1.05335	3.0192	17.6575	0.21115	11.74	0.0004	0.2819	0.0065
WP	67.089	0.00225	0.00305	0.0335	2.39195	3.6095	22.4585	0.2161	13.1305	0.00125	1.7445	0.01235
MM	44.0715	0.0022	0.0013	0.02995	0.54175	0.61315	16.506	0.1551	8.3167	0.00625	0.4444	0.00435
YM	52.9095	0.00255	0.00325	0.0405	1.2854	0.8867	20.225	0.0714	11.139	0.00682	0.2943	0.0137

Appendix C.

Water quality data measured with field meters. Site names are given in Appendix A

Site	pH	Conductivity	Temp	Turbidity (NTU)
PMSGA	8	1419	17.8	20.1
ESGA	8.2	516	20.2	50.4
LEM	8.4	339	23	7.1
PP	9.1	284	31.1	6.6
SM	10.2	327	30	12.6
WP	8.9	580	n/a	241.0
MM	8.7	309	23.1	29.0
YM	8.8	283	27.1	26.3

Appendix D.

Plant taxa collected in transects in each coastal wetland

Point Mouillee SGA	**Erie SGA**	**Lake Erie Metropark**	**Potter's Pond**	**Sheldon's Marsh NP**	**Willow Point WA**	**Metzger's Marsh**	**Young Marsh**
Submergents: *Ceratophyllum demersum, Elodea canadensis*	**Submergents**: *Ceratophyllum demersum, Elodea canadensis, Potamogeton pusillis pusillis, P. richardsoni, Zosterella dubia*	**Submergents:** *Ceratophyllum demersum, Elodea canadensis, Myriophyllum spicatum, Potamogeton pectinatus, Vallisneria americana, Zosterella dubia*	**Submergents:** *Ceratophyllum demersum, Elodea canadensis, Myriophyllum spicatum, Potamogeton crispus, P.pusillus pusillus, Zannichellia palustris, Zosteralla dubia*	**Submergents:** *Ceratophyllum demersum, Potamogeton sp.*	**Submergents:** *Potamogeton crispus, P. pectinatus*	**Submergents:** *Ceratophyllum demersum, Elodea canadensis, Najas minor, Potamogeton crispus, P. pusillus pusillus, Utricularia vulgaris, Vallisneria americana, Zosterella dubia*	**Submergents:** *Najas minor*
Emergents: *Acer negundo, Butomus umbulatus, Convolvulus sepium, Cornus amomum, Elymus*	**Emergents:** *Asclepius incarnata, Cirsium arvense, Cuscuta gronovii, Cyperus odoratus,*	**Emergents:** *Acer saccarinum, Ailanthus altissima, Bidens sp. ,*	**Emergents:** *Alisma subcordatum, Ammania robusta, Asclepias*	**Emergents:** *Alisma subcordatum, Ammania robusta , Bidens sp., Cirsium*	**Emergents:** *Acer negundo, Carex sp., Cirsium arvense, Convolvulus sepium, Cornus amomum,*	**Emergents:** *Acer negundo, A. saccharinum, Alisma subcordatum, Asclepias*	**Emergents:** *Alisma subcordatum, Cirsium arvense, Convolvulus sepium,*

virginicus, Fraxinus americana, F. pennsylvanica, Geum canadense, Glechoma hederacea, Impatiens capensis Lemna sp., Nepeta cataria, Parthenocissus virginicus, Phalaris arundinacea, Phragmites australis, Populus deltoids, Potamogeton nodosus, Sagittaria latifolia, Salix nigra, Schoenoplectus tabernaemontani, Solanum dulcamara, Spirodela sp., Teucrium canadense,

Eleocharis acicularis, E. erythropoda, E. smallii, Hibiscus palustris, Impatiens capensis, Juncus torreyi, Leerzia orozoides, Lysimachia ciliata, Lythrum salicaria, Menta arvensis, Nelumbo lutea, Phalaris arundinacea, Phragmites australis, Polygonum caespitosum, P. punctatum, P. nodusus, Rorippa palustris, Sagittaria latifola, Sambucus Canadensis, Schoenoplectus tabernaemontani, S. fluviatilis, Solanum

Boehmeria cylindrical, Butomus umbulatus, Unknown Dicot#1, Cirsium arvense, Cuscuta gronovii, Echinochloa walterii, E. pungens, Impatiens capensis, Lemna minor, Spirodela polyrhiza, Lysimachia ciliata, Lythrum salicaria, Morus alba, Nymphea odorata, Parthenocissus quinquifolia,

incarnata, Bidens cernua, Cyperus sp., Eleocharis acicularis, Juncus sp., Justicia Americana, Leersia oryzoides, Lemna minor, Ludwigia palustris, Lycopus asper, Lythrum salicaria, Phalaris arundinacea, Phragmites australis, Polygonum punctatum, Potamogeton nodosus,, Sagittaria sp., Schoenoplectus tabernaemontani, S. fluviatilis,,

arvense, Cornus amomum, Cyperus odoratus, Eleocharis erythrorhizos, Epilobium coloratum, Eupatorium perfoliatum , Impatiens capensis, Juncus effusus , J. torreyi, Leersia oryzoides, Lemna sp., Ludwigia palustris, Lycopus europeaus, Mimulus ringens, Nuphar advena, Phalaris arundinacaea, Phragmites australis , Polygonum punctatum,

Eleocharis sp., Epilobium coloratum, Eupatorium perfoliatum, Hibiscus sp. Impatiens capensis, Juncus torreyi, J. uniflorus, Leersia oryzoides, Lemna sp., Lysimachia ciliata, Lythrum salicaria, Phalaris arundinacea, Phragmites australis, Populus deltoids, Quercus palustris, Rosa multiflora , Sagittaria latifolia, Salix eriocephala S. exigua, S. nigra, S. sp., Schoenoplectus fluviatilis. S. tabernaemontani, S. atrovirens,

incarnata, Boehmeria cylindrical, Butomus umbellatus, Cornus sericea, Eleocharis erythropoda, E. acicularis,, Juncus articus, Eleocharis smallii, Impatiens capensis, Lycopus americanus, Lythrum salicaria, Parthenocissus quinquifolia, Phragmites australis, Polygonum amphibium, Populus deltoids, Potamogeton nodosus, Robinia

Eleocharis erythropoda, Epilobium coloratum, Hibiscus palustris, Impatiens capensis, Juncus effuses, Leersia oryzoides, Lythrum salicaria, Mimulus ringens, Nelumbo lutea, Phragmites australis, Polygonum punctatum, Pontederia cordata, Potamogeton nodosus, Sagittaria latifolia, Salix exigua, S. nigra, Schoenoplectus tabernaemontani,

Toxicodendron radicans, Typha glauca/augustifolia, Unknown dicot #1, Vitis riparia	*dulcamara, Spirodela sp., Typha angustifolia/glauca, Utrica dioaca, Verbena hastata*	*Phragmites australis, Pilea pumila, Polygonum sp., Ranunculus scleratus, Sagitaria latifolia, Salix exigua, S. nigra, Sambucus Canadensis, Scrophularia marilandica, Solanum dulcamara, Teucrium canadense, Typha glauca / angustifolia, Unknown Dicot #2, Urtica dioaca, Verbena hastate, Vitis riparia*	*Sparganium eurycarpum, Spirodela polyrhiza, Typha angustifolia*	*Populus deltoids, Sagittaria latifolia, Salix discolor, S. exigua, S. nigra , Samolus parviflorus, Schoenoplectus tabernaemontani, Sparghanium eurycarpum, Typha angustifolia , Unknown dicot#1, Unknown dicot#2, Unknown Dicot #3, Verbena hastata*	*Solidago Canadensis, Sparganium eurycarpum, Typha augustifolia/glauca, Ulmus rubra, Unknown Cyperaceae, Unknown dicot , Unknown Graminaceae, Urtica dioaca , Verbena hastate, Vitis riparia*	*pseudoacacia, Sagittaria latifolia, Salix exigua, S. nigra , Schoenoplectus fluviatilis S. tabernaemontani, Solidago gigantea, Spirodela sp., Typha augustifolia, Unknown Cyperaceae, Unknown dicot #1, Unknown dicot#2, Verbena hastata*	*Sparghanium eurycarpum, Typha augustifolia*

Appendix E.

Fish collected at coastal wetlands. Trap Type indicates the method used to collect fish: MT = Minnow trap; FN = Fyke Net; Total = data from Minnow traps and Fyke nets combined. Species list indicates the species collected at each wetland: Bc = Black Crappie; Bf = Bowfin; Bg = Bluegill; Bk = Banded Killifish; Blb = Black Bullhead; Bmbf = Bigmouth Buffalo; Brb = Brown Bullhead; Bs = Brook Silversides; Carp = Common Carp; Cc = Channel Catfish; Es = Emerald Shiner; Gf = Goldfish; Gsf = Green Sunfish; Lmb = Largemouth Bass; Lng = Long-Nosed Gar; Lp = Logperch; Ps = Pumpkinseed; Rb = Rock Bass; Rg = Round Goby; Smb = Smallmouth Bass; Ss = Spottail Shiner; Wb = White Bass; Wc = White Crappie; Wp = White Perch; Yb = Yellow Bullhead; Yp = Yellow Perch

Site	**Trap type**	**# Fish collected**	**# Species**	**# Fish w/DELTS**	**Species list (* = found DELT)**
Erie State Game Area	MT	7	4	2	Bg, Gf*, Brb, Lmb
	FN	225	10	34	Bf, Bg*, Bs, Brb*, Carp*, Gf*, Gs*, Lmb, Ss, Wb
	TOTAL	232	10	36	
Lake Erie Metropark	MT	81	4	2	Bk*, Bg*, Lmb, Rg, Ps
	FN	382	16	7	Bk, Bg*, Bc, Bf*, Carp*, Cc, Es, Gf, Gsf, Gs, Lmb, Lng, Ss, Rb, Rg, Ps
	TOTAL	463	16	9	
Point Mouillee	MT	11	4	0	Carp, Gf, Lmb, Bg
	FN	145	14	0	Bs, Bg, Bf, Carp, Es, Gs, Lmb, Lp, Rg, Smb, Wb, Cc, Ps, Ss

	TOTAL	156	15	0	
Potters Pond	MT	5	2	0	Gsf, Lmb
	FN	75	11	0	Bk, Bg, Bf, Brb, Carp,Gs, Gsf, Lmb, Wp, Wb, Es
	TOTAL	80	11	0	
Metzgers Marsh	MT	98	4	0	Brb, Bg, Gf, Lmb
	FN	280	14	3	Brb, Bg, Bc, Bf, Carp, Gs, Lmb, Ps, Rb, Rg, Lng, Yb, Yp, Es
	TOTAL	378	15	3	
Sheldon's Marsh	MT	131	5	3	Blb*, Bg, Carp, Gf, Gsf
	FN	952	12	15	Bg*, Blb*, Carp*, Bmbf, Cc, Gf*, Gs, Gsf, Ps, Es, Bs, Unknown Cyprinid
	TOTAL	1083	12	18	
Willow Point	MT	45	8	1	Bg, Carp*, Cc, Gf, Gs, Gsf, Lmb, Yb
	FN	534	12	1	Bg, Bmbf*, Carp, Cc, Gf, Gs, Gsf, Lng, Wb, Yb, Yp, Es
	TOTAL	579	13	2	
Young Marsh	MT	46	6	0	BG, CARP, GSF, LMB, WC, YB
	FN	799	9	2	BF, BG, GF, GS*, LMB, WB, WC, YB*, YP
	TOTAL	845	10	2	

Appendix F.

Invertebrates collected with activity traps. Site names are given in Appendix A

		Site							
TAXA	**GENUS**	**PMSGA**	**ESGA**	**LEM**	**PP**	**SM**	**WP**	**MM**	**YM**
Oligochaeta	Not id'ed	X	X	X	X	X	X	X	X
Erpobdellidae	Not id'ed		X						
Glossophoniid	Placobdella	X		X	X			X	X
Ancylidae	Ferrissia								
Hydrobiidae	Amnicola								
Lymnaeidae	Fossaria								
	Pseudosuccinea	X							X
	Stagnicola								
	Radix								
	Physella	X		X	X		X	X	X
Planorbidae	Gyraulus			X			X	X	
	Helisoma				X				
Hydrobiidae	Amnicola					X			
Dreissenidae	Dreissena	X							
Sphaeriidae	Not id'ed		X						
Talitridae	Hyallela	X		X	X	X		X	X
Gammaridae	Gammarus	X	X	X	X				X
Cambaridae	not id'ed								
Paleomonidae	Paleomonetes								X
Isopoda	Caecadotia								
Hydracarina	Not id'ed	X	X	X	X	X	X	X	X
Entomobryidae	Not id'ed	X						X	

Poduridae	Podura	X	X						
Sminthuridae	Not id'ed				X				
Baetidae	Callibaetis								X
Caenidae	Caenis		X	X	X			X	X
Hexageniidae	Hexagenia								
Coenagrionidae	Ishnura				X		X		
	Coenagrion/Enallagma	X	X	X	X	X	X	X	X
	Enallagma								X
Aeschnidae	Anax					X			
Libellulidae	Perithemis					X			X
	Tramea								
	Pachydiplax								
	not id'ed								
Belostomatidae	Belostoma				X	X	X		
Corixidae	Trichocorixa	X	X	X	X	X	X	X	X
	Hesperocorixa								
	Corisella								
	Palmacorixa							X	
Gerridae	Gerris								
	Rheumatobates				X				
Hydrometridae	Hydrometer								
Mesoveliidae	Mesovelia	X	X		X		X	X	
Veliidae	Microvelia							X	
Naucoridae	Pelocoris								
Nepidae	Ranatra							X	
Notonectidae	Notonecta				X	X	X		
Pleidae	Neoplea								

Sialidae	Sialis								X
Haliplidae	Peltodytes					X			X
Dytiscidae	Hydrovatis						X		
	Laccophilus					X	X		
	Uvarus								X
Hydrophilidae	Tropisternus					X	X		
	Berosus								
	Enochrus								
Noteridae	Hydrocanthus								
Gyrinidae	Gyrinus								
	Dineutes						X		
Chrysomelidae	Donacia								
Curculionidae	Onychilis								
Ceratopogonidae	Culicoides						X		X
	Not id'ed			X	X	X		X	
Chaoboridae	Chaoborus							X	
Chironomidae	Not id'ed	X	X	X	X	X	X	X	X
Culicidae	Anopheles			X	X		X		
	not id'ed								
Stratiomyidae	Odontomyia					X			
Sciomyzidae	not id'ed								
Pyralidae	Acentria	X							
	Parapoynx								
Hydroptilidae	Oxyethira								
	Ochrotrichia								
	Orthotrichia								
	Agraylea								X

Leptoceridae	Oecetis	X		X	X				
	TOTAL	**119**	**518**	**216**	**472**	**3131**	**216**	**446**	**454**
	Richness	**16**	**11**	**14**	**20**	**16**	**17**	**17**	**20**

Appendix G.

Invertebrates sampled with sweep nets and live – sorted. Site names are given in Appendix A

		Site							
TAXA	**SPECIES**	**PMSGA**	**ESGA**	**LEM**	**PP**	**SM**	**WP**	**MM**	**YM**
Oligochaeta	Not id'ed	X	X	X	X	X	X	X	X
Erpobdellidae	Not id'ed			X				X	
Glossophoniid	Placobdella			X					X
Ancylidae	Ferrissia								
Hydrobiidae	Amnicola			X					
Lymnaeidae	Fossaria	X				X			X
	Pseudosuccinea	X	X						X
	Stagnicola	X							
	Radix			X					
Physidae	Physella	X	X	X	X	X	X	X	X
Planorbidae	Gyraulus			X				X	X
	Helisoma	X			X				
Prosobranch	not id'ed								
Dreissenidae	Dreissena	X							
Sphaeriidae	Not id'ed		X						X
Talitridae	Hyallela	X		X				X	X
Gammaridae	Gammarus	X	X	X	X			X	X
Cambaridae	not id'ed						X		
Paleomonidae	Paleomonetes								X
Isopoda	Caecadotia								
Hydracarina	Not id'ed	X	X	X	X	X		X	X
Poduridae	Podura	X							

Baetidae	Callibaetis	X	X		X		X		X
Caenidae	Caenis	X	X	X	X		X	X	X
Hexageniidae	Hexagenia				X				X
Coenagrionidae	Ishnura	X		X	X			X	
	Coenagrion/Enallagma	X	X	X	X		X	X	X
	Enallagma	X		X	X			X	
Aeschnidae	Anax	X	X	X	X		X	X	X
Libellulidae	Erythemis					X			
	Tramea								
	Pachydiplax				X			X	
	not id'ed								
Belostomatidae	Belostoma	X	X		X	X	X	X	
Corixidae	Trichocorixa	X	X		X	X	X	X	X
	Hesperocorixa						X		
	Corisella								
Gerridae	Gerris	X	X		X		X		X
	Rheumatobates	X							
Hydrometridae	Hydrometer		X						
Mesoveliidae	Mesovelia	X	X	X	X		X	X	X
Veliidae	Microvelia							X	
Naucoridae	Pelocoris							X	
Nepidae	Ranatra	X					X		X
Notonectidae	Notonecta				X	X	X		
Pleidae	Neoplea	X							
Haliplidae	Peltodytes	X				X			
Dytiscidae	Laccophilus				X		X		
	Uvarus								

Hydrophilidae	Tropisternus		X		X		X		
	Berosus	X					X		
	Enochrus			X				X	
Noteridae	Hydrocanthus				X			X	
Gyrinidae	Gyrinus				X			X	X
Chrysomelidae	Donacia		X						
Curculionidae	Onychilis								X
Ceratopogonidae	Culicoides		X			X	X	X	X
	Not id'ed			X	X		X	X	X
Chironomidae	Not id'ed	X	X	X	X	X	X	X	X
Culicidae	Anopheles	X		X			X		
	not id'ed								
Stratiomyidae	Odontomyia					X			
Sciomyzidae	not id'ed								
Pyralidae	Acentria				X				
	Parapoynx			X					
Hydroptilidae	Oxyethira								X
	Ochrotrichia								
	Orthotrichia							X	
	Agraylea	X		X					
Leptoceridae	Oecetis	X		X	X		X	X	
	TOTAL numbers	**540**	**1032**	**482**	**943**	**84**	**468**	**675**	**324**
	richness	**30**	**19**	**23**	**26**	**12**	**22**	**26**	**26**

Appendix H.

Invertebrates collected with sweep nets and laboratory sorted. Site names are given in Appendix A

		Site							
TAXA	**GENUS**	**PMSGA**	**ESGA**	**LEM**	**PP**	**SM**	**WP**	**MM**	**YM**
Oligochaeta	Not id'ed	X	X	X	X	X	X	X	X
Glossophoniid	Placobdella				X				X
Ancylidae	Ferrissia	X			X				
Lymnaeidae	Fossaria	X			X	X	X	X	X	X
	Pseudosuccinea	X							X
Physidae	Physella	X	X	X	X	X	X	X	X
Planorbidae	Gyraulus	X		X	X			X	
	Helisoma		X		X				
Hydrobiidae	Amnicola	X		X					
Dreissenidae	Dreissena	X			X				
Hyalellidae	Hyallela	X		X	X			X	X
Gammaridae	Gammarus	X	X	X				X	
Cambaridae	not id'ed						X		
Paleomonidae	Paleomonetes								X
Isopoda	Caecadotia	X							
Hydracarina	Not id'ed		X	X	X	X	X	X	X
Baetidae	Callibaetis	X		X			X		X
Caenidae	Caenis	X	X	X	X	X	X	X	X
Coenagrionidae	Ishnura	X	X	X	X	X	X	X	X
Aeschnidae	Anax	X	X	X	X		X		X
Libellulidae	Tramea	X	X						
	Pachydiplax							X	

	not id'ed			X					X
Belostomatidae	Belostoma	X	X	X	X			X	
Corixidae	Trichocorixa	X	X		X	X	X	X	X
	Corisella						X		
Gerridae	Gerris	X	X	X	X			X	X
	Rheumatobates								X
Mesoveliidae	Mesovelia	X	X	X	X	X	X	X	X
Veliidae	Microvelia		X					X	
Naucoridae	Pelocoris								X
Nepidae	Ranatra	X			X			X	X
Notonectidae	Notonecta		X		X	X	X		X
Pleidae	Neoplea	X					X		
Dytiscidae	Laccophilus						X		
	Uvarus			X					
Hydrophilidae	Tropisternus						X		
	Berosus	X		X			X		
	Enochrus			X				X	
Noteridae	Hydrocanthus		X						
Gyrinidae	Gyrinus				X				
Curculionidae	Onychilis						X		
Ceratopogonidae	Culicoides	X	X	X	X	X		X	X
	Not id'ed	X	X	X	X	X	X	X	X
Chironomidae	Not id'ed	X	X	X	X	X	X	X	X
Culicidae	Anopheles			X				X	
	not id'ed				X				
Stratiomyidae	Odontomyia			X		X			
Sciomyzidae	not id'ed							X	

Pyralidae	Acentria	X	X	X	X			X	
	Parapoynx			X				X	
Hydroptilidae	Oxyethira	X	X	X	X	X		X	X
	Ochrotrichia			X					
	Orthotrichia			X	X				X
	Agraylea	X		X					X
Leptoceridae	Oecetis	X	X	X	X		X	X	X
	Total	**2778**	**7906**	**6424**	**4596**	**531**	**2122**	**5746**	**1368**
	Richness	**30**	**22**	**33**	**26**	**14**	**21**	**26**	**27**

Appendix I.

Trichoptera species collected in light traps. Note: Traps deployed at Young Marsh (YM) were lost during a storm. Site names are given in Appendix A. *** indicates new state record for species

	SITE							
SPECIES	**PM**	**ESGA**	**LEM**	**PP**	**SM**	**WP**	**MM**	**YM**
Oecetis cinerascens	X	X	X	X	X	X	X	N/a
Oecetis immobilis	X	X	X	X	X		X	N/a
Oecetis inconspicua	X	X	X	X	X	X	X	N/a
Trianodes abus							X	N/a
Polycentropus cinereus	X							N/a
Cyrnellus fraternus					X		X	N/a
Hydropsyche sp.	X	X			X	X		N/a
Hydroptila spatulata	X		X					N/a
Hydroptila waubesiana	X	X	X	X	X	X	X	N/a
Orthotrichia aegerfasciella	X	X	X		X	X	X	N/a
Oxyethira pallida	X	X	X	X	X	X	X	N/a
Oxyethira verna							X***	N/a
Oxyethira zeronia							X	N/a
Agraylea multipunctata	X	X	X	X	X	X	X	N/a
Ochrotrichia tarsalis	X***			X	X		X	N/a
Oecetis females	X	X			X	X		N/a
Hydroptila spp. female	X	X	X	X	X		X	N/a
Hydropsyche sp. nr. *slossonae*					X			N/a
								N/a
Total	**601**	**277**	**116**	**351**	**407**	**130**	**240**	N/a
Richness	**11**	**8**	**8**	**7**	**10**	**7**	**12**	N/a