AN EVALUATION OF THE PRESQUE ISLE BAY WATERSHED FISH COMMUNITY: 2001 - 2011

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Sea Grant
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Great Lakes
RESTORATION

TABLE OF CONTENTS

1.0 ABSTRACT

The Presque Isle Bay watershed, located in northwestern Pennsylvania, drains a highly urbanized area (62.6% imperviousness) of approximately 26.2 square miles. Tributaries of the bay include Scott Run, Cascade Creek, Mill Creek, and Garrison Run. It has been well documented that urbanization can alter biotic communities and cause declines in the diversity of fishes. Species richness, diversity, and a multi-metric index of biological integrity were used to investigate changes in the Presque Isle Bay watershed fish community at 12 locations between 2001 and 2011. Species richness was significantly higher among the 12 sites in 2011 (mean = 4.9) compared to 2001 (mean = 3.8). The number of sensitive species was higher in 2011 (n = 5) compared to 2001 (n = 2); however, tolerant species dominated the catch in both years. The diversity of fish, calculated using the Shannon-Wiener Diversity Index (H'), was low in 2001 (H' = 1.41) and 2011 (H' = 1.35). In 2001 and 2011, western blacknose dace and creek chub comprised the majority of the catch; 77.28% and 80.03%, respectively. Comparison of index of biotic integrity (IBI) scores from 2011 and 2001 suggests that the Presque Isle Bay watershed as a whole still remains poor; however, the average IBI score improved from 25 in 2001 to 32 in 2011, and the IBI scores improved at nine of the 12 sites. The assessment of fish communities in this study, along with future assessments, will enable the identification and prioritization of the impact of stream improvement projects.

2.0 INTRODUCTION

Presque Isle Bay is a 5.7 square-mile (14.8 square-kilometer) embayment located in northwestern Pennsylvania on the southern shore of Lake Erie. The bay's watershed drains a highly urbanized area (62.6% imperviousness) of approximately 26.2 square miles (67.9 square kilometers), including portions of Millcreek Township, City of Erie, Harborcreek Township, Summit Township, and Greene Township in Erie County, Pennsylvania. Named tributaries of the bay include, from west to east, Scott Run, Cascade Creek, Mill Creek, and its tributary Garrison Run (**Map 1**). These tributaries comprise 88.3% of the bay's watershed; the remainder of the watershed (11.7%) is comprised of small unnamed tributaries and direct runoff to the bay.

It has been well documented that urbanization can result in degraded ecosystems (Paul and Meyer 2008). Alterations in stream flow, channel morphology, and biotic communities have been attributed to urbanization (reviewed by Wang *et al.* 2001). As urbanization increases so does the volume of stormwater runoff, resulting in more intense flooding events that de-stabilize stream banks causing erosion, loss of pool habitat and stream cover, scouring, and deposition. These changes, combined with degraded water quality, can alter biotic communities and cause declines in the diversity of invertebrates and fishes (Wang *et al.* 2001). Klein (1979) observed decreased fish diversity in urban streams, Klauda *et al.* (1998) observed decreased fish IBI scores in streams with greater than 50% urban land uses, and Wang *et al.* (2000) observed decreased species richness and IBI scores in watersheds with greater than 10% impervious cover.

Karr (1981) first introduced the concept of using the IBI to assess the ecological integrity of small warmwater streams, citing several advantages of using fish as indicator organisms. Karr *et al.* (1986) suggests that "biotic integrity is possessed by aquatic ecosystems in which composition, structure, and function have not been adversely impacted by human activities, and when looked at as a whole, chemical, physical, and biotic integrity can be equated with ecological integrity." The IBI uses the characteristics of fish assemblages to evaluate the biological integrity and includes scoring 12 metrics related to species composition, trophic composition, and fish abundance and condition. The sum of the 12 metrics yields an overall site score that characterizes the biotic integrity of the site. Since its development, the IBI has been modified and applied to various regions of the United States (Barbour *et al.* 1999). Pyron *et al.*

(2004) developed a modified IBI to assess the fishery of the Presque Isle Bay watershed.

In 2010, The *Presque Isle Bay Watershed Restoration, Protection, and Monitoring Plan* (referred to as the *Plan*) was developed to provide a framework for action that would ensure that activities throughout the Presque Isle Bay watershed would not cause adverse impacts to the bay's ecosystem (Rafferty *et al.* 2010). The *Plan* provides a model to drive coordinated restoration, protection, and monitoring projects within the watershed. Measuring the success of watershed restoration and protection efforts relies heavily upon a long-term watershed monitoring plan, including monitoring the physical, chemical, and biological integrity of the watershed. Pyron *et al.* (2004) provided a baseline assessment of the Presque Isle Bay watershed fish community by assessing a total of 12 sites along Scott Run, Cascade Creek, Mill Creek, and Garrison Run using a modified IBI developed by Ohio EPA (1987). The long-term monitoring plan calls for the 12 sites to be re-assessed every five years, beginning in 2011, in an effort to track improvements to the fish community as a result of restoration actions within the watershed.

The objective of this study was to evaluate the fish community of the Presque Isle Bay watershed at the 12 sites assessed by Pyron *et al.* (2004), in accordance with the monitoring recommendations of the *Plan*, and to compare current IBI results to those observed by Pyron *et al.* (2004).

3.0 METHODOLOGY

In June 2011, a fish community assessment was conducted at 12 sites along the tributaries of Presque Isle Bay (**Map 2**; **Table 1**). All sites were previously sampled by Pyron *et al.* (2004) in summer 2001. At each site, a 100-meter stream section was sampled using a Smith Root Model 15-D backpack electrofisher equipped with a Honda generator. The electrofisher was set to mode I5, which represents a standard pulsed direct current wavelength of 60Hz at 6ms. The output voltage ranged from 100 to 300 volts. Electrofishing consisted of a one-pass electrofishing effort, working in a side-to-side pattern between the left and right banks. Electrofishing was conducted in an upstream direction and all habitat types were sampled (e.g. (riffles, runs, and pools). When possible, natural barriers such as riffles and waterfalls were used as starting and ending points. The electrofishing start and end times were recorded in order to calculate effort (i.e. catch per hour). Field crews consisted of three-five crew members. A minimum of two crew members were CPR and First Aid certified and at least one crew member was a taxonomic specialist. For crews of three, one crew member operated the electrofisher while the other two crew members netted fish and transferred fish to five-gallon buckets. For crews of four, one crew member operated the electrofisher, two crew members netted fish, and one crew member transferred fish to five-gallon buckets. For crews of five, one crew member operated the electrofisher, three crew members netted fish, and one crew member transferred fish to five-gallon buckets.

Immediately following the sampling, fish were transferred to 17.5 gallon holding tanks with ice. Fish were identified and enumerated in the field, and all fish data were recorded on the *2011 Pennsylvania Lake Erie Stream Fish Sampling Data Sheet* (**Appendix A**). All species identified in the field were released. Species not identifiable in the field were anesthetized and then transferred to 10% buffered formalin. The preserved species were transported to the Natural History Museum at the Tom Ridge Environmental Center for identification. Prior to identification, fish were fixed in 10% buffered formalin for five to 14 days (duration of fixation was dependent on the size, shape, and number of fish). The fish were then transferred to de-ionized water for two days, then 20% un-denatured ethyl alcohol for two days, then 40% un-denatured ethyl alcohol for two days, and finally the samples were preserved in 70% un-denatured ethyl alcohol. Following fixation, fish were identified according to Trautman (1981), Werner (2004), and Page and Brooks (2011). All preserved specimens are housed at the Natural History Museum at the Tom Ridge Environmental Center. Species unidentifiable at the museum were shipped to Dr. Jay Stauffer, Distinguished Professor of Ichthyology at Penn State University, for identification.

A modified, multi-metric fish IBI was used to assess the biotic integrity of the Presque Isle Bay watershed streams (Ohio EPA 1987 and Pyron *et al.* 2004). A total of 12 metrics, representing three classes of biological attributes (species richness and composition, fish condition and abundance, and trophic composition) were evaluated (Table 2). Each metric was scored against criteria based on expectations developed from reference sites. Metric values approximating, deviating slightly from, or deviating greatly from values occurring at the reference sites were scored as 5, 3, and 1, respectively. The scores of the 12 metrics were then summed for each site to produce an IBI score, ranging from a maximum of 60 (excellent) to a minimum of 12 (very poor). Sites were then classified according to Karr (1981) and Karr *et al.* (1986) as excellent, excellent-good, good, good-fair, fair, fair-poor, poor, poor-very poor, or very poor (Table 3). In addition, sites were classified according to Yoder (1995) as meeting warmwater habitat use designation when IBI scores exceeded 40.

Water quality and site characteristic data were also recorded at each site. The latitude and longitude of the downstream limit were recorded at each site using a Garmin GPSMAP® 60CSX handheld GPS unit. Dissolved oxygen, temperature, pH, and conductivity were measured at each site using a Quanta® Hydrolab. The channel width was determined by averaging five measured wetted channel widths (measured every 20 meters) using a graduated measuring tape. The stream depth was determined by averaging five depth measurements taken from a cross-section of the stream.

4.0 RESULTS

4.1 Species richness and diversity

In 2011, a total of 2,724 individual fish representing 17 species from seven families were collected within the Presque Isle Bay watershed (Table 4). Minnows (*Cyprinidae*) were the dominant family in the watershed, comprising 90.2% of the total catch. Other families that contributed to the total catch were sculpins (*Cottidae*) at 2.83%, perch (*Percidae*) at 2.46%, suckers (*Catostomidae*) at 2.39%, sunfish (*Centrarchidae*) at 0.95%, trout (*Salmonidae*) at 0.84%, and catfish (*Ictaluridae*) at 0.33%. Western blacknose dace (*Rhinichthys obtusus*) and creek chub (*Semotilus atromaculatus*) comprised the majority of species collected, 50.22% and 29.81% respectively (Figure 1). Central stoneroller (*Campostoma anomalum*), mottled sculpin (*Cottus bairdi*), rainbow darter (*Etheostoma caeruleum*), and white sucker (*Catostomus commersoni*) comprised 9.84%, 2.83%, 2.42%, and 2.39% of the total catch, respectively. Each of the other 11 species collected made up less than 1.0% of the total catch. Site SR1 had the lowest species richness, two species were observed, and the lowest total number of fish with14.. Site CC1 had the highest species richness; 11 species were observed. Site MC6 had the highest total number of fish with948.

In 2001, Pyron *et al.* (2004) collected a total of 889 individual fish representing 13 species from six families (Table 5). Minnows were the dominant family in the watershed, comprising 82.34% of the total catch. Other families that contributed to the total catch were suckers at 11.25%, sculpins at 2.59%, perch at 2.25%, sunfish at 1.46%, and gobies (*Gobiidae*) at 0.11%. Creek chub and western blacknose dace comprised the majority of species collected, 45.78% and 31.50%, respectively (Figure 2). White sucker, central stoneroller, mottled sculpin, and rainbow darter comprised 11.25%, 4.27%, 2.59%, and 2.14% of the total catch, respectively. The other five species collected made up less that 1.0% of the total catch. Site GR1 had the lowest species richness and lowest total number of fish; no fish were observed. Sites CC1 and MC1 had the highest species richness; seven species were observed at each site. MC1 had the highest total number of fish with199 fish.

More species of fish were observed at sites CC1, CC6, MC1, MC3, MC6, and GR1 in 2011 than in 2001; however, more species were observed at site MC5 in 2001 than in 2011 (Table 6; Figure 3). Sites SR1, CC2, CC4, MC4, and MC8 had the same number of species present in both 2011 and 2001.

A Wilcoxon Signed-Rank Test indicates that species richness was significantly higher in 2011 compared to 2001 ($n = 7$; $W = 1.5$; $p < 0.05$). More total fish were observed at all sites, except SR1, when sampled in 2011 (**Figure 4**). Western blacknose dace, blugill (*Lepomis macrochirus*), central stoneroller, creek chub, mottled sculpin, pumpkin seed (*Lepomis gibbosus*), rainbow darter, rock bass (*Ambloplites rupestris*), and white sucker were observed in both 2011 and 2001 (**Table 7**). Brown bullhead (*Ameiurus nebulosus*), emerald shiner (*Notropis atherinoides*), goldfish (*Carassius auratus*), logperch (*Percina caprodes*), longnose dace (*Rhinichthys cataractae*), rainbow trout (*Oncorhynchus mykiss*), spottail shiner (*Notropis hudsonius*), and yellow bullhead (*Ameiurus natalis*) were only observed in 2011. Round goby (*Neogobius melanostomus*), fathead minnow (*Pimephales promelas*), bluntnose minnow (*Pimephales notatus*), and yellow perch (*Perca flavescens*) were only observed in 2001.

4.2 Index of Biotic Integrity (IBI)

In 2011, IBI scores for the 12 sites ranged from a low of 24 at sites CC4, CC6, and MC4 to a high of 40 at site MC1 (**Table 8**; **Figure 5**). The average IBI for the 12 sites was 32, indicating the watershed as a whole is in poor condition. Site MC1 was the only site to meet the acceptable warmwater habitat criteria (IBI score ≥ 40), and MC1 was the only site to receive a fair classification. Longnose dace, mottled sculpin, rainbow darter, rainbow trout, and spottail shiner were the only species collected that are sensitive to habitat or water quality degradation; comprising only 6.34% of the total catch in 2011 (**Table 9**). Tolerant species (blacknose dace, bluegill, brown bullhead, central stoneroller, creek chub, goldfish, white sucker, and yellow bullhead) comprised 92.74% of the total catch

In 2001, no fish were collected at site GR1 and the highest calculated IBI score was 36 at sites MC1, MC5, MC6, and MC8 (**Table 10**; **Figure 6**) (Pyron *et al.* 2004). The average IBI for the 12 sites was 25, indicating the watershed as a whole was in poor-very poor condition. None of the sites met the acceptable warmwater habitat criteria (IBI Score ≥ 40) and none of the sites received a classification above fair-poor. Mottled sculpin and rainbow darter were the only species collected that are sensitive to habitat or water quality degradation, comprising only 4.73% of the total catch in 2001 (**Table 11**). Tolerant species (blacknose dace, bluegill, bluntnose minnow, central stoneroller, creek chub, fathead minnow, and white sucker) comprised 93.69% of the total catch.

Improved IBI scores were observed at sites SR1, CC1, CC2, CC6, MC1, MC3, MC4, MC6, and GR1 in 2011 compared to 2001, and there was no change in IBI scores at sites CC4, MC5, and MC8 (**Table 12**; **Figure 7**). A Wilcoxon Signed-Rank Test indicates that the IBI scores were significantly higher in 2011 compared to 2001 ($n = 9$; $W = 0.0$; $p < 0.001$)

4.3 Water Quality and Site Data

Temperatures ranged from a low of 13.73°C (56.71°F) at site GR1 to a high of 19.38°C (66.88°F) at site CC1 (**Table 13**; **Figure 8**). Specific conductance ranged from a low of 525 µS cm^{-1} at site MC4 to a high of 1,680 µS cm^{-1} at site CC6 (**Figure 9**). Dissolved oxygen concentrations ranged from a low of 6.52 mg L^{-1} at site CC6 to a high of 8.29 mg L^{-1} at site MC3 (**Figure 10**). The pH ranged from 7.95 at CC4 to 8.83 at site MC3 (**Figure 11**). Stream widths ranged from 1.5 meters (5.0 feet) at site MC4 to 12.6 meters (41.2 feet) at site MC 1 (**Figure 12**). Stream depths ranged from 7.1 centimeters (2.8 inches) at site MC4 to 34.3 centimeters (13.5 inches) at site GR1 (**Figure 13**).

5.0 DISCUSSION

A total of 2,724 fish were collected in 2011 compared to 889 in 2001. This represents a three-fold increase. In 2011, 948 fish were collected at site MC6; this represents more fish than was collected at the

12 sites combined in 2001. In 2011, 17 species representing seven families were observed compared to 13 species representing six families in 2001. In 2011, the range of species richness at the 12 sites was 2 to 11 (mean = 4.9) compared to 0 to 7 (mean = 3.8) in 2001. Increases in species richness were observed at six sites in 2011 while only site MC5 had a decrease in species from 2001. Despite the increase in species observed in 2011, the diversity was low in both years. In 2011, for the 12 sites combined, blacknose dace and creek chub comprised 80.03% of the total catch, whereas, 11 of the remaining species each made up less than 1.0% of the total catch. In 2001, blacknose dace and creek chub comprised 77.28% of the total catch and seven of the remaining species each made up less than 1.0% of the total catch. In addition, the Shannon Index, which considers the abundance and evenness of species, was similar in 2001 and 2011; 1.41 and 1.35, respectively. In contrast, Andraso *et al.* (2009) observed a more even distribution of species in Crooked Creek (Shannon Index = 3.98), a non-urbanized stream located 16 miles west of the Presque Isle Bay watershed.

The functional groups of species collected in the Presque Isle Bay watershed may be more important than the species richness and diversity. The number of sensitive species observed increased from two in 2001 to five in 2011, which included longnose dace, spottail shiner, and rainbow trout in addition to mottled sculpin and rainbow darter. Sensitive species were observed at eight sites in 2011 compared to only four sites in 2001. In 2011, rainbow trout were collected at sites SR1 and CC1; whereas, no rainbow trout were collected in 2001. However, there was no significant difference in the number of sensitive species between years ($n = 5$; $W = 2.5$; $p > 0.05$). Despite the increase in sensitive species, the tolerant species dominated the catch in both years. In 2001 and 2011, seven tolerant species were observed and tolerant species were collected at each site. Moreover, the percentage of the total catch represented by tolerant species was similar in 2001 and 2011; 93.69% and 92.74%, respectively.

Comparison of IBI scores from 2011 and 2001 suggests that the Presque Isle Bay watershed as a whole still remains in poor condition; however, the average IBI score improved from 25 (poor-very poor) in 2001 to 32 (poor) in 2011, and the IBI scores improved at nine of the 12 sites. Despite the improved IBI scores, site MC1 was the only location to meet the acceptable warmwater habitat criteria (IBI ≥ 40) for Ohio headwater streams (Yoder 1995); none of the sites sampled in 2001 met the attainment criteria. The Ohio warmwater habitat criteria is considered to be met in waters capable of supporting and maintaining a balanced, integrated, adaptive community of warmwater aquatic organisms having a species composition, diversity, and functional organization comparable to the 25^{th}-percentile of the reference sites. In addition, MC1 (2011) was the only location to receive a fair classification established by Karr (1986); all other sites sampled in 2001 and 2011 were classified at poor or very poor. The poor classification suggests that the stream is dominated by omnivores, tolerant species, and habitat generalists, and few top carnivores are present. The very poor classification indicates that few fish are present and most fish are tolerant species.

Wang *et al.* (2000) observed decreased species richness and IBI scores in watersheds with greater than 10% impervious cover. Impervious cover within the Presque Isle Bay watershed has remained at approximately 63% over the past decade. However, the species richness and IBI scores in the watershed have significantly improved over the past ten years. In 2011, both improved IBI scores and species richness were observed at sites CC1, CC6, MC3, MC6, and GR1. Northington and Hershey (2006) found higher species richness in urban stream sites in the North Carolina Piedmont where stream channel and riparian restoration efforts had been implemented. The improved species richness and IBI score observed at site CC1 may be explained by the upstream-stabilization of 1,900 linear feet of Cascade Creek between 2006 and 2010, which has resulted in the elimination of an estimated 149.0 tons of sediment per year from entering Cascade Creek and improved in-stream habitat. In contrast, Stranko *et al.* (2011) found no significant differences in species richness or IBI scores in restored urban streams when compared to urban streams. There was no increase in species richness at site CC2, which is located downstream from the restored sections of Cascade Creek; however, an improved IBI score was observed.

Ohio EPA (1992) observed decreased IBI scores in Riley Creek, upstream and downstream from the Bluffton Wastewater Treatment Plant. The impaired fish community was attributed to episodic overflows from combined sewer overflows (CSOs) and subsequent organic enrichment. In 2001, no fish were observed at site GR1. Pyron *et al.* (2004) attributed the absence of fish to the presence of oily material on the water surface, almost no natural substrate material, and noxious smells. In 2011, four species of fish were observed at site GR1, including the sensitive species mottled sculpin. From 1996 to 2005, nine CSOs from the Erie Wastewater Treatment Plant to Garrison Run were eliminated (M. Kwitowski, personal communication). In 1995, remediation of the National Fuel Gas Distribution Corporation Wayne Street Facility was completed. Prior to the remediation of the site, groundwater contaminated with polychlorinated biphenyls, heavy metals, polycyclic aromatic hydrocarbons, and cyanide would leach into Garrison Run. The elimination of contaminated groundwater and CSOs are likely responsible for the improved species richness and IBI score at site GR1.

In conclusion, the fish community of Scott Run, Cascade Creek, Mill Creek, and Garrison has improved since 2001. However, the fish community as a whole still remains in poor condition. Both improvements in the IBI score and species richness at site CC1 suggest that stream stabilization and riparian restoration may enhance the fishery. Continually assessing the fish community of the Presque Isle Bay watershed in the future will provide a mechanism for measuring the impact of future restoration efforts on the fish community.

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APPENDIX A: FORMS

Appendix A: 2011 Pennsylvania Lake Erie Stream Fish Sampling Data Sheet

Stream/Watershed:_____ **Site Name:**_____

Researcher Name(s):_____ **Date:**_____

Latitude: _____ **Longitude:**_____

Start Time:_____ **End Time:**_____ **Weather:**_____

Stream Depth:_____ **Stream Width:**_____

Stream Temp:_____ **D.O.**_____ **Conductivity:** _____ **pH:**_____

Alewife	
American Brook Lamprey	
Banded Killifish	
Bigeye Chub	
Black Crappie	
Black Redhorse	
Blackside Darter	
Bluegill	
Bluntnose Minnow	
Bowfin	
Brindled Madtom	
Brook Silverside	
Brook Stickleback	
Brook Trout	
Brown Bullhead	
Brown Trout	
Central Mudminnow	
Central Stoneroller	
Channel Catfish	
Channel Darter	
Chinook Salmon	
Coho Salmon	
Common Carp	
Common Shiner	
Creek Chub	
Eastern Sand Darter	
Emerald Shiner	
Fantail Darter	
Fathead Minnow	
Flathead Catfish	
Freshwater Drum	
Gizzard Shad	
Golden Rainbow Trout	
Golden Redhorse	
Golden Shiner	
Goldfish	
Grass Carp	
Grass Pickerel	
Greenside Darter	
Hornyhead Chub	
Iowa Darter	
Johnny Darter	
Lake Chubsucker	
Largemouth Bass	

Appendix A: 2011 Pennsylvania Lake Erie Stream Fish Sampling Data Sheet

Logperch	
Longnose Dace	
Longnose Gar	
Longnose Sucker	
Mimic Shiner	
Mottled Sculpin	
Muskellunge	
Northern Brook Lamprey	
Northern Hogsucker	
Northern Pike	
Pearl Dace	
Pink Salmon	
Pumpkinseed	
Rainbow Darter	
Rainbow Smelt	
Rainbow Trout	
Redfin Shiner	
Redside Dace	
River Chub	
Rock Bass	
Rosyface Shiner	
Round Goby	
Rudd	
Sand Shiner	
Sea Lamprey	
Shorthead Redhorse	
Silver Chub	
Silver Lamprey	
Silver Redhorse	
Silver Shiner	
Silverjaw Minnow	
Smallmouth Bass	
Spotfin Shiner	
Spottail Shiner	
Spotted Gar	
Spotted Sucker	
Stonecat	
Striped Shiner	
Tadpole Madtom	
Tiger Muskellunge	
Walleye	
Warmouth	
Western Blacknose Dace	
White Bass	
White Crappie	
White Perch	
White Sucker	
Yellow Bullhead	
Yellow Perch	
DELTS	

Return to Page 2

APPENDIX B: FIGURES

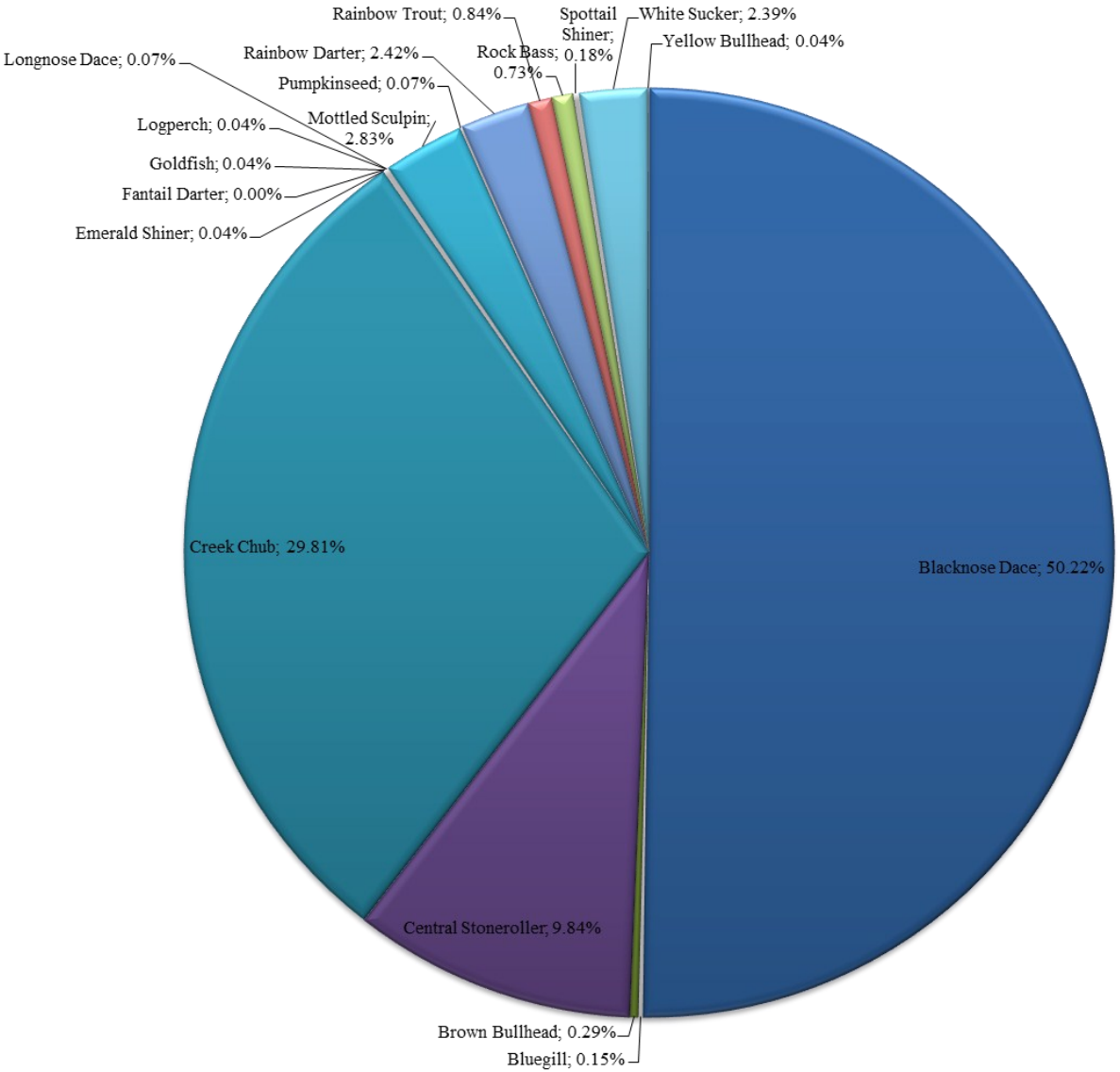


Figure 1. Fish community structure in the Presque Isle Bay watershed: 2011

Return to Page 3

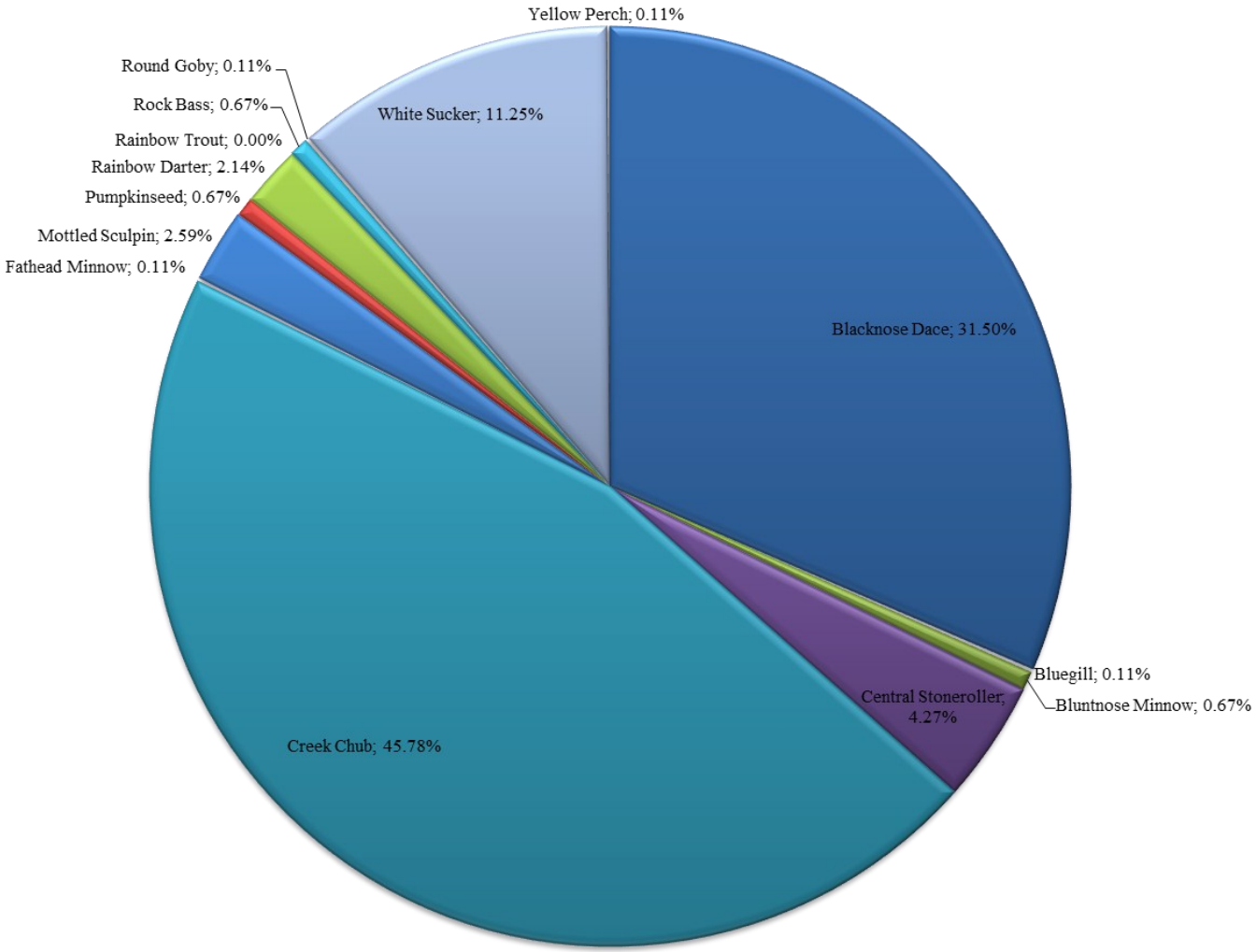


Figure 2. Fish community structure in the Presque Isle Bay watershed: 2001

Return to Page 3

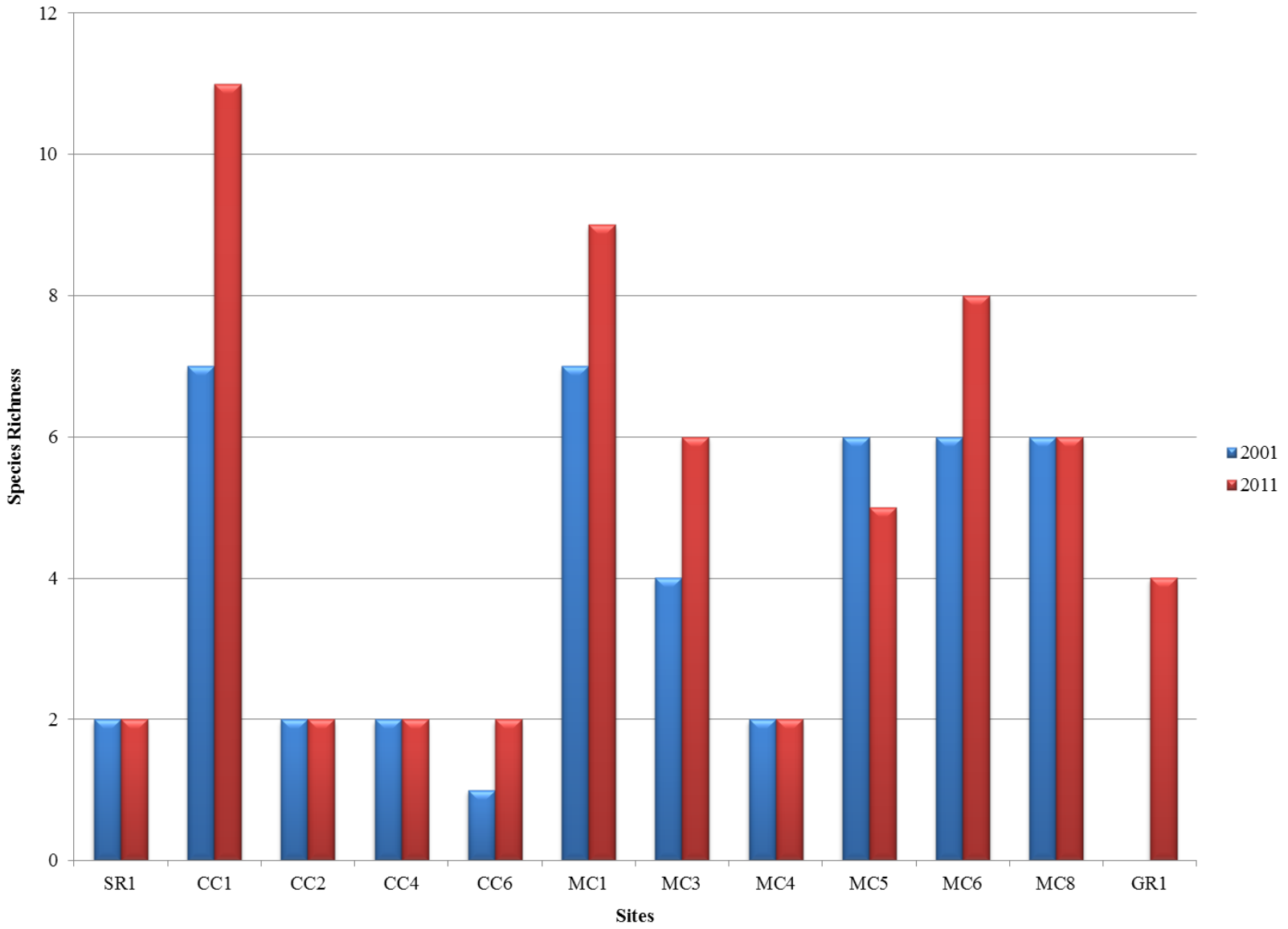


Figure 3. Fish species richness in the Presque Isle Bay watershed: 2001—2011

Return to Page 3

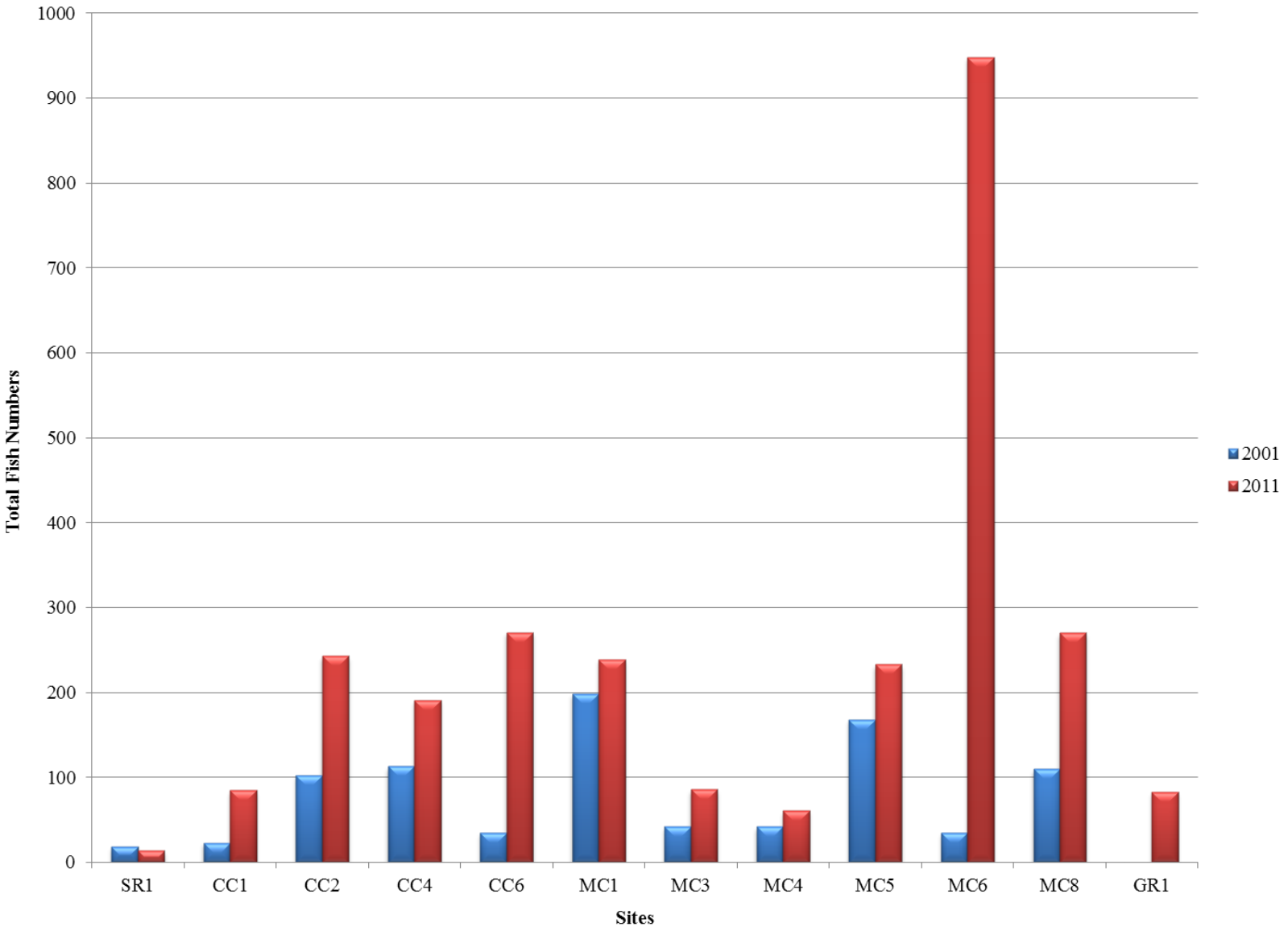


Figure 4. Total fish numbers in the Presque Isle Bay watershed: 2001—2011

Return to Page 4

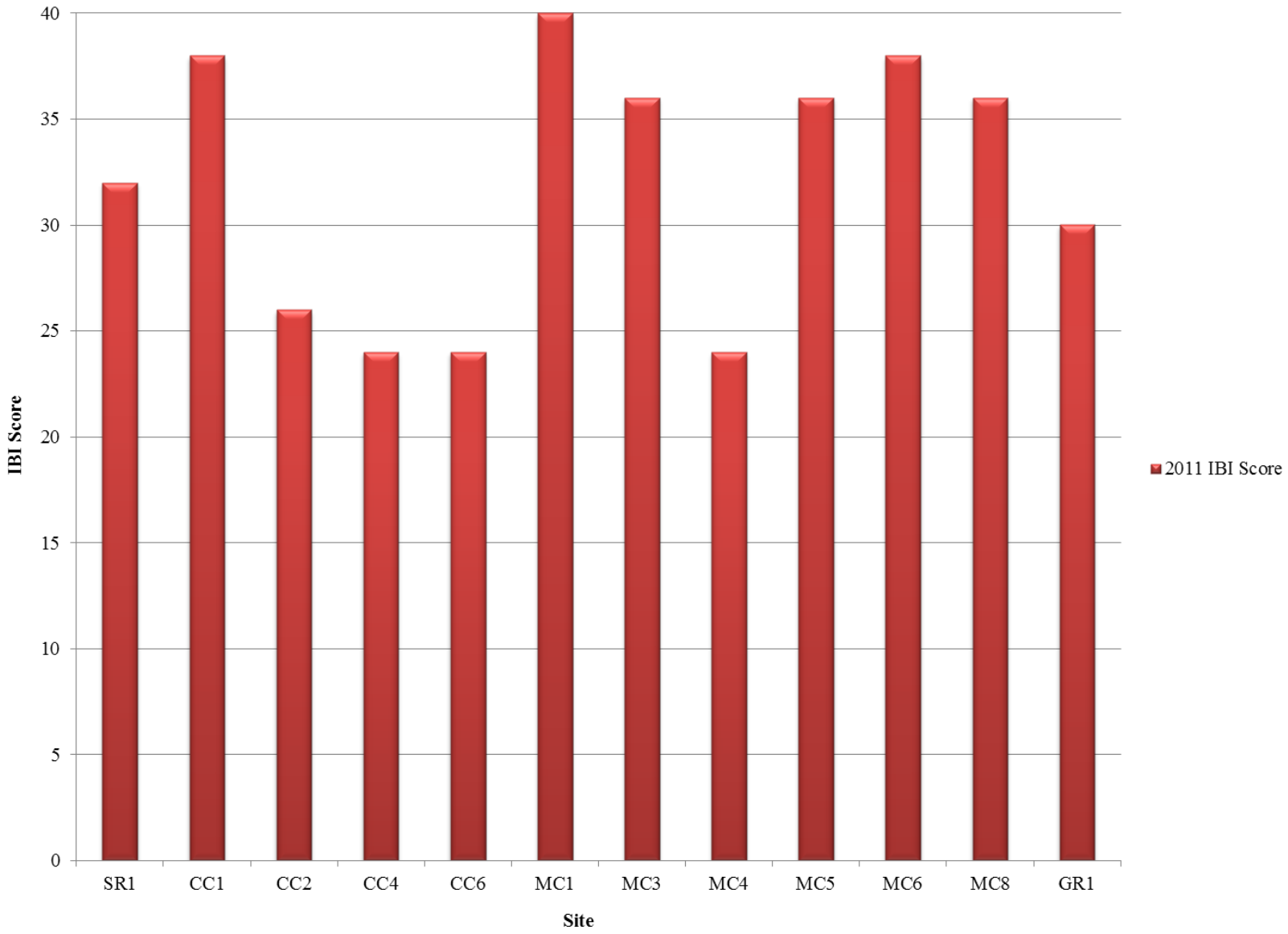


Figure 5. Index of biotic integrity (IBI) scores in the Presque Isle Bay watershed: 2001

Return to Page 4

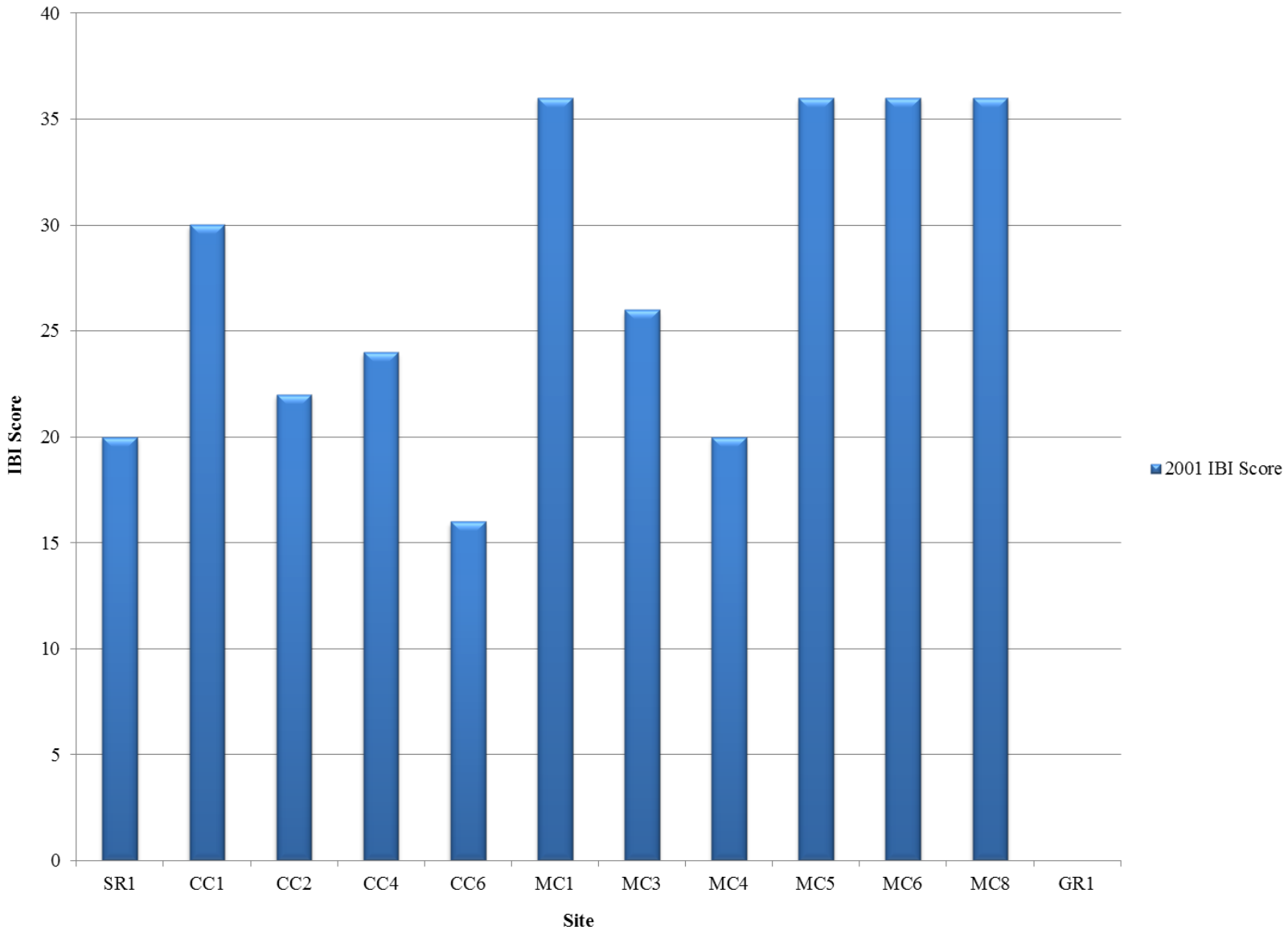


Figure 6. Index of biotic integrity (IBI) scores in the Presque Isle Bay watershed: 2011

Return to Page 4

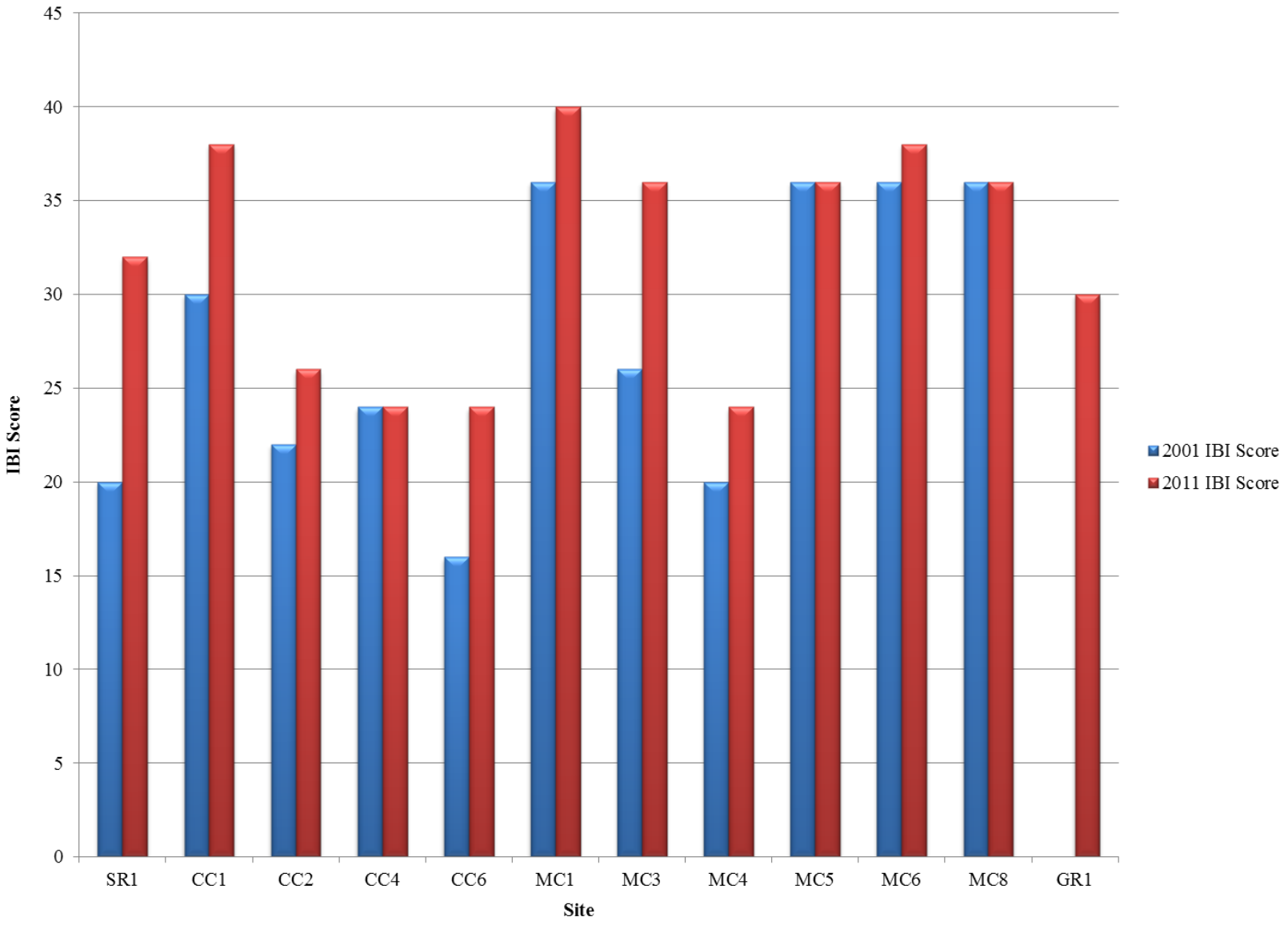


Figure 7. Fish IBI scores in the Presque Isle Bay watershed: 2001—2011

Return to Page 4

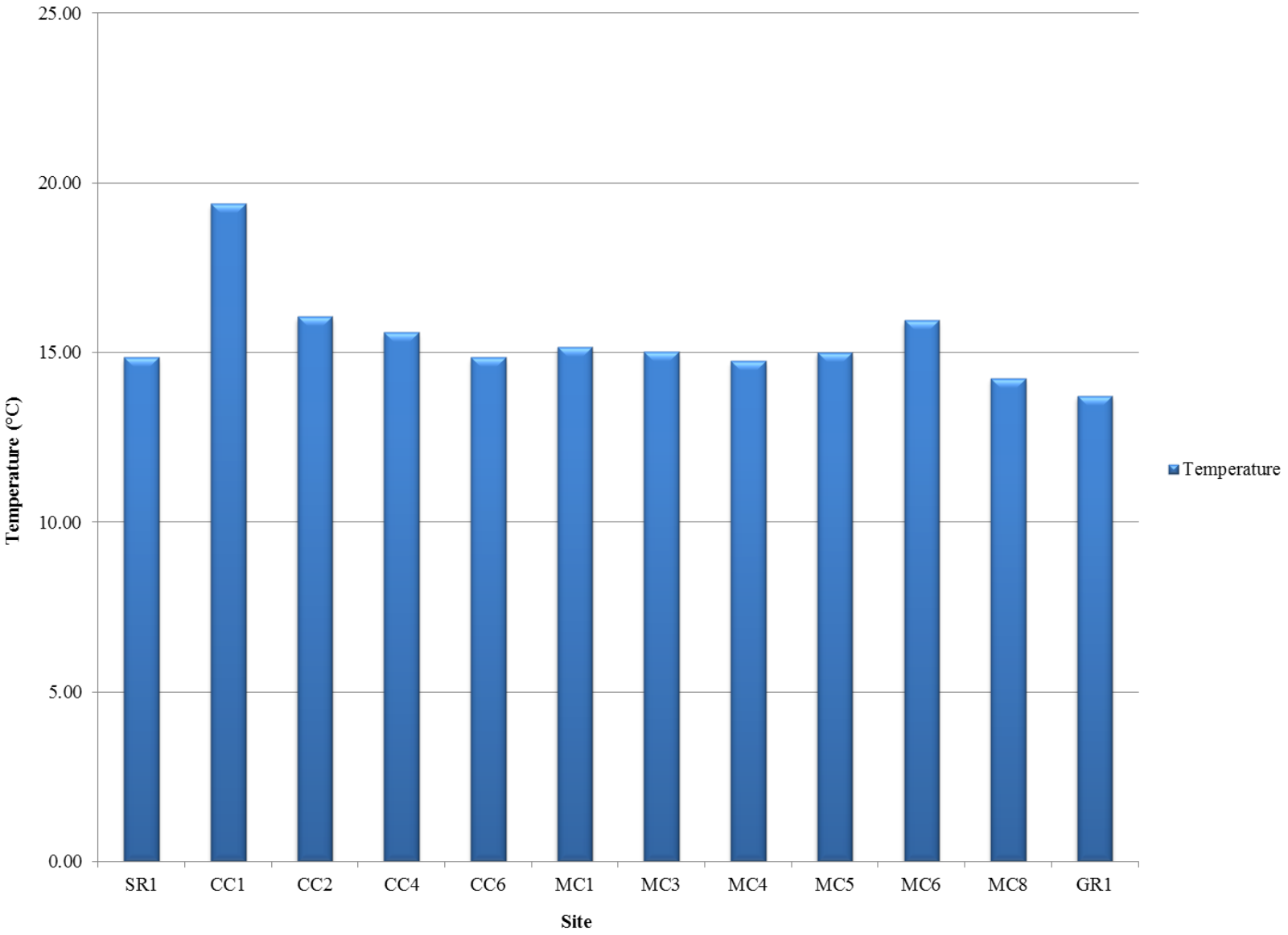


Figure 8. Water temperatures in the Presque Isle Bay watershed: 2011

Return to Page 4

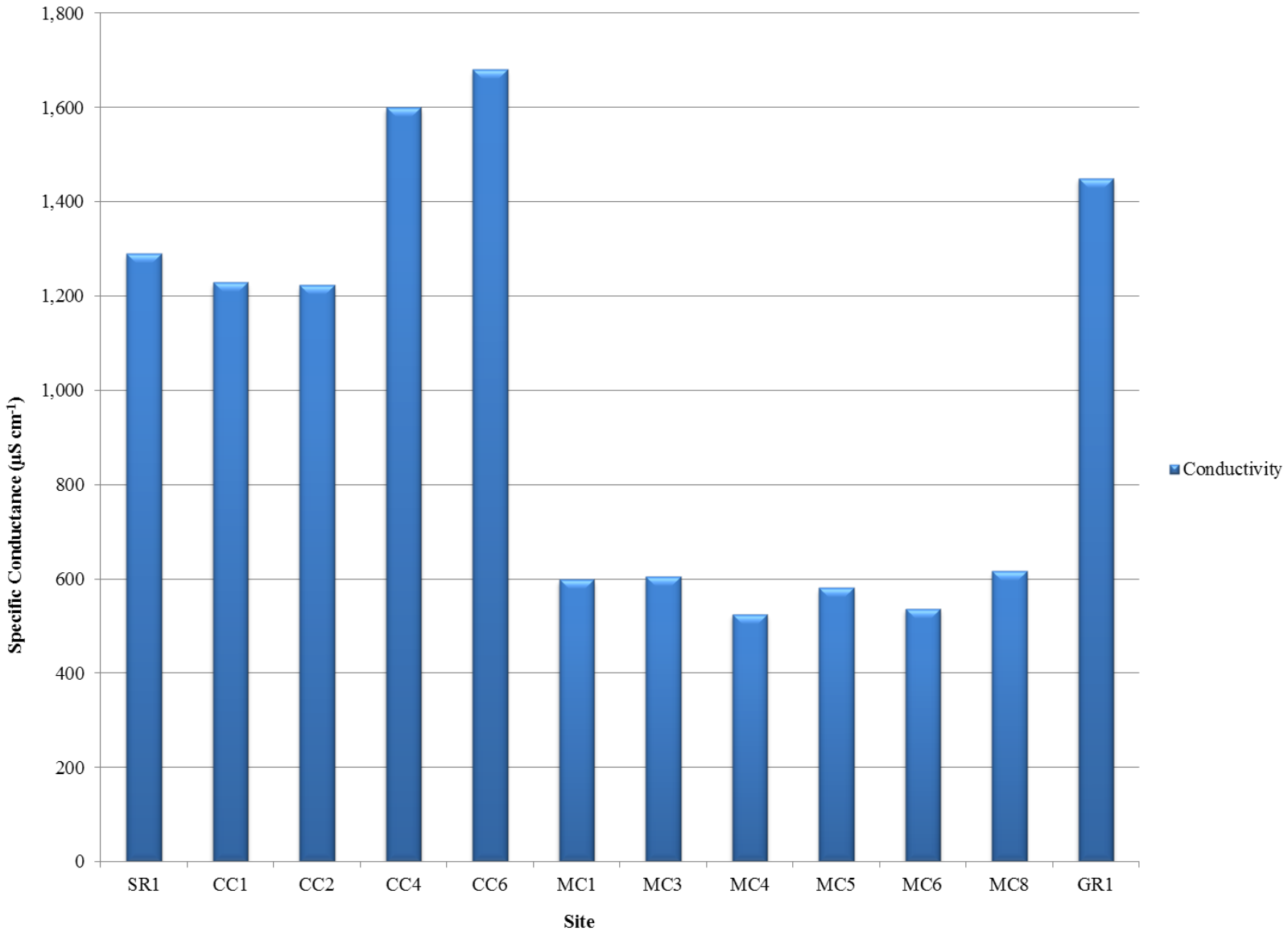


Figure 9. Specific conductance in the Presque Isle Bay watershed: 2011

Return to Page 4

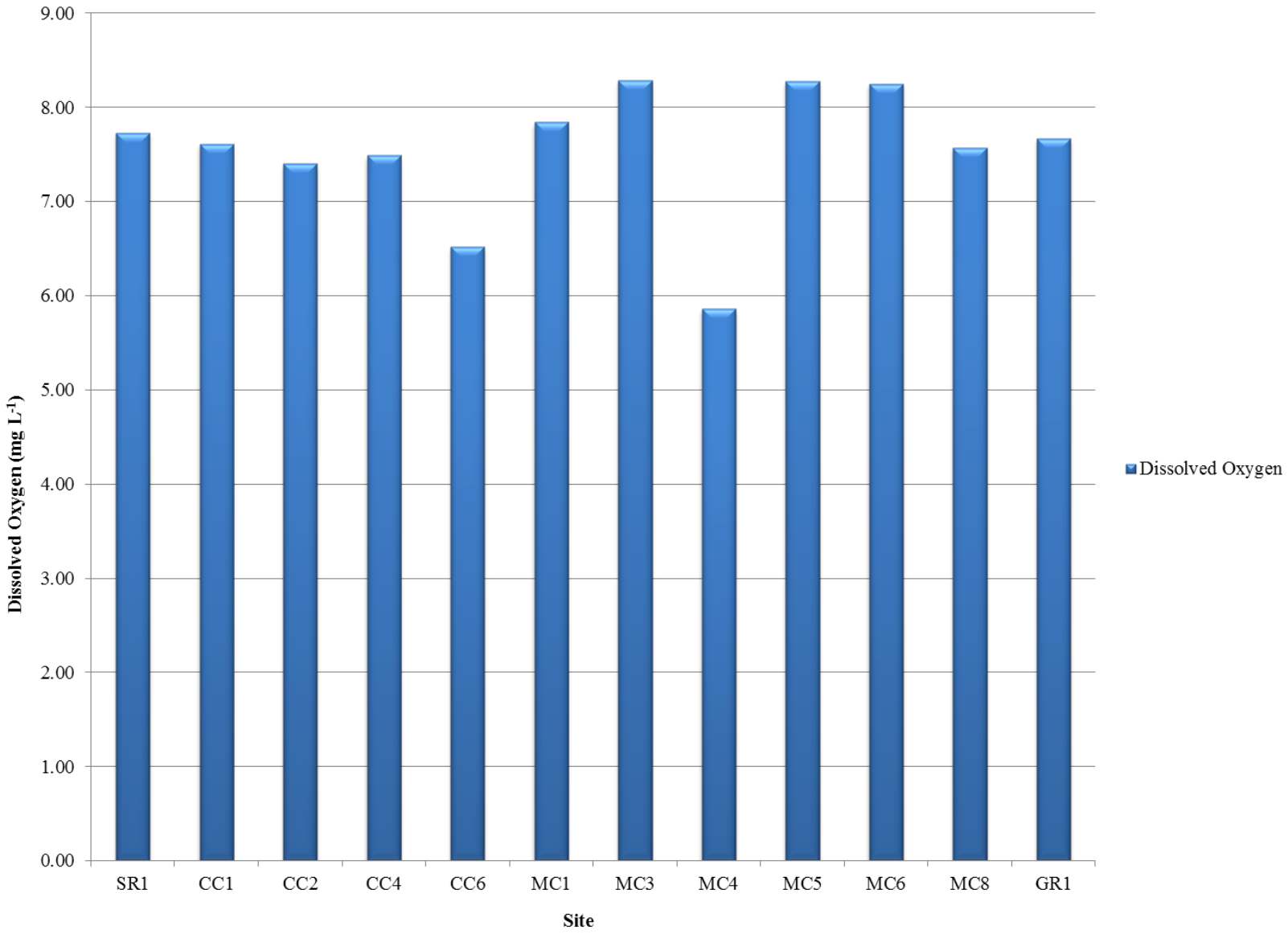


Figure 10. Dissolved oxygen concentrations in the Presque Isle Bay watershed: 2011

Return to Page 4

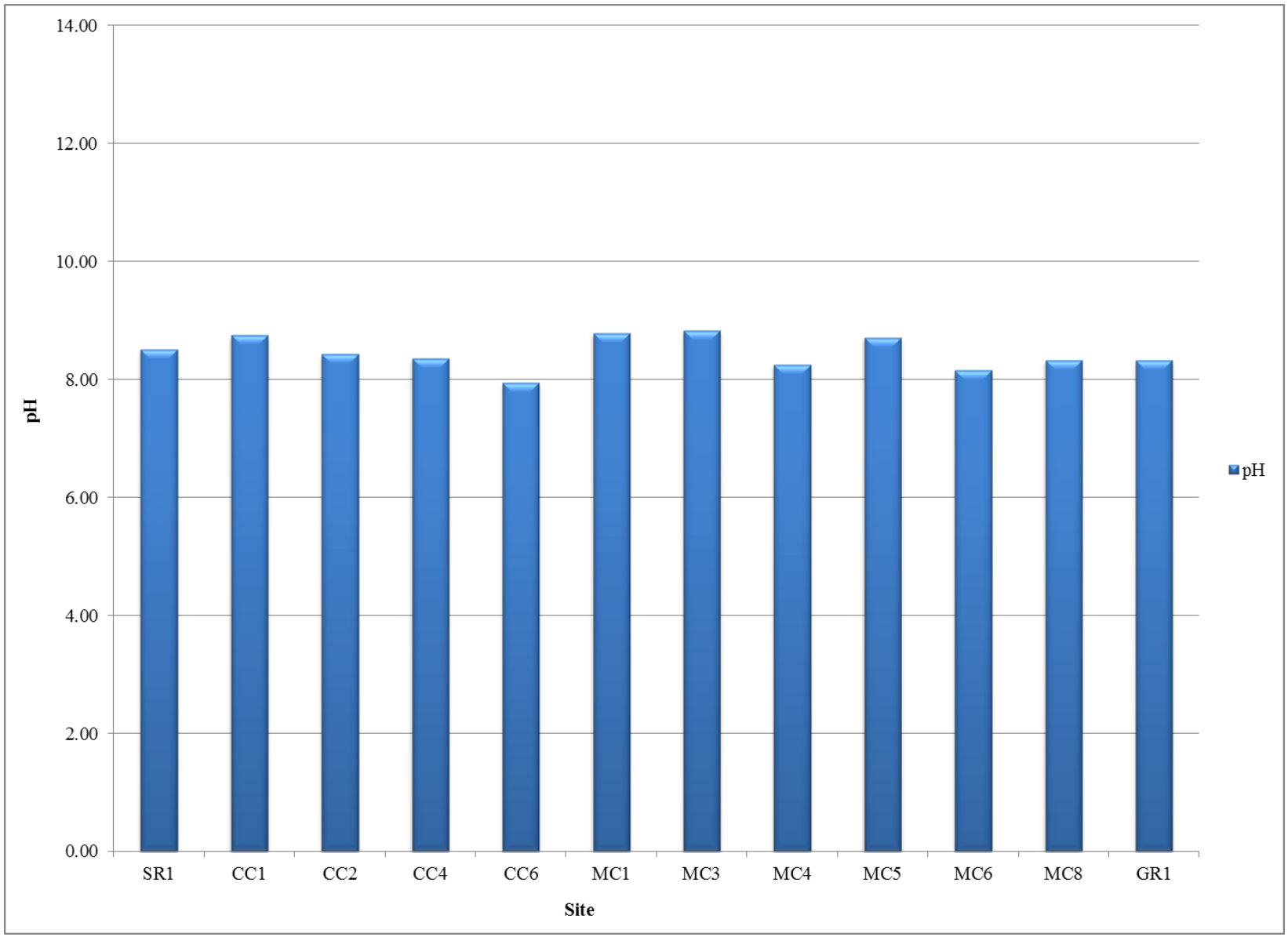


Figure 11. pH values in the Presque Isle Bay watershed: 2011

Return to Page 4

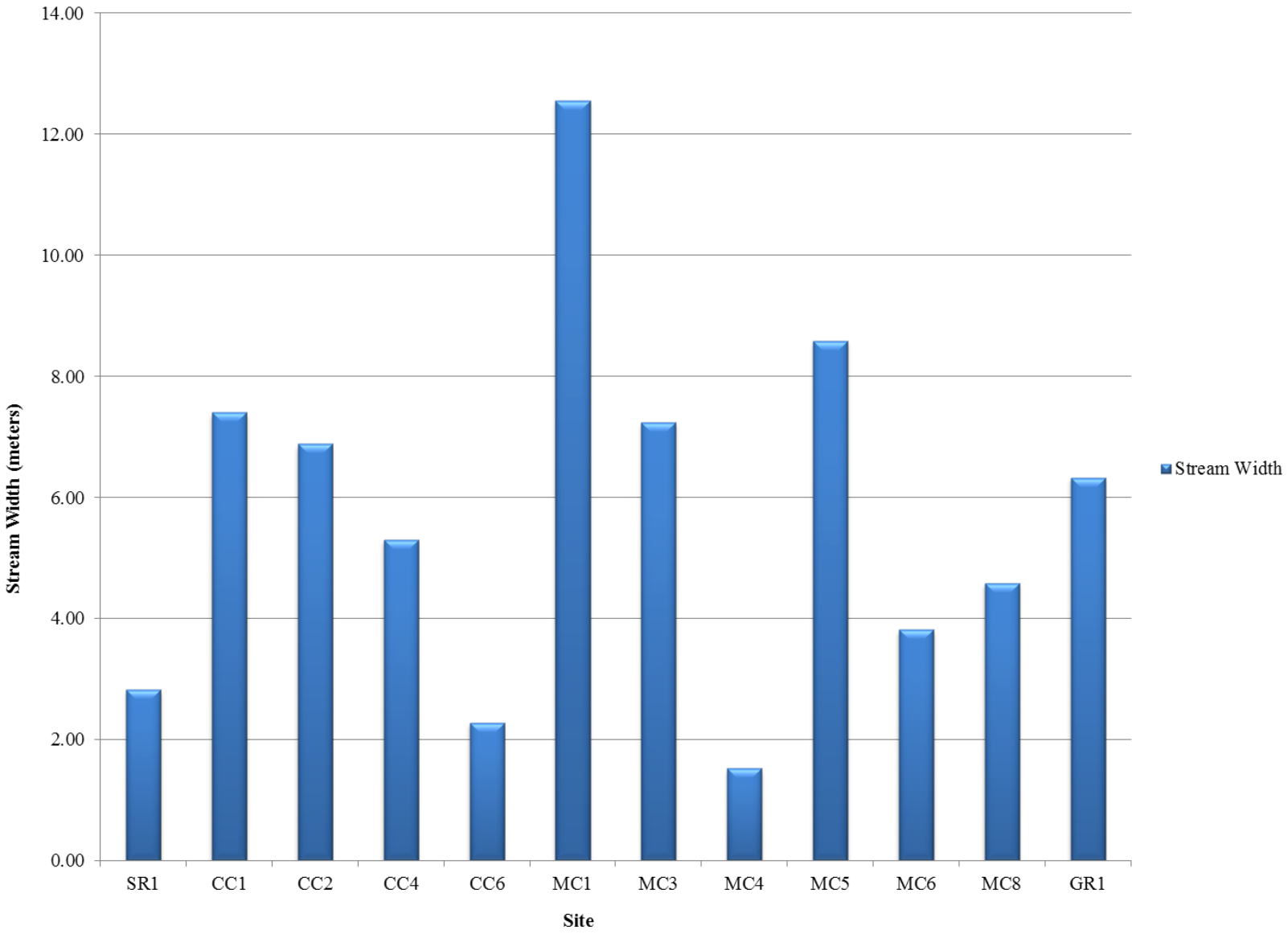


Figure 12. Stream widths in the Presque Isle Bay watershed: 2011

Return to Page 4

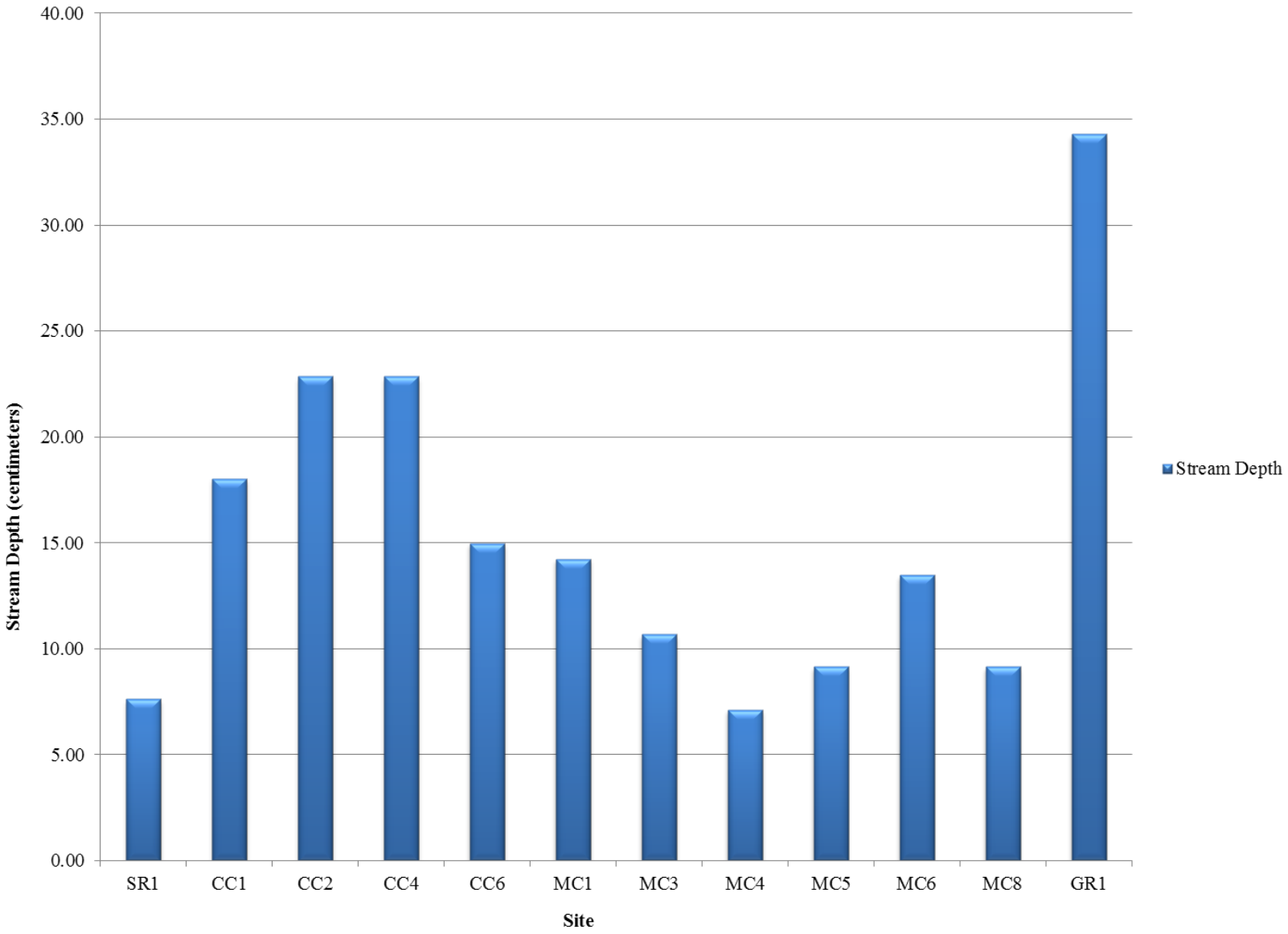


Figure 13. Stream depths in the Presque Isle Bay watershed: 2011

Return to Page 4

APPENDIX C: TABLES

Table 1. 2011 Presque Isle Bay tributary fish sampling locations

Stream	Site	Date	Latitude	Longitude
Scott Run	SR 1	June 10, 2011	42.11074	-80.1554
Cascade Creek	CC 1	June 8, 2011	42.12635	-80.11705
Cascade Creek	CC 2	June 8, 2011	42.11679	-80.1172
Cascade Creek	CC 4	June 10, 2011	42.11069	-80.12428
Cascade Creek	CC 6	June 10, 2011	42.10172	-80.1308
Mill Creek	MC 1	June 13, 2011	42.10508	-80.07337
Mill Creek	MC 3	June 14, 2011	42.09311	-80.07106
Mill Creek	MC 4	June 14, 2011	42.07717	-80.05166
Mill Creek	MC 5	June 14, 2011	42.09203	-80.05516
Mill Creek	MC 6	June 14, 2011	42.10323	-80.026737
Mill Creek	MC 8	June 13, 2011	42.09093	-80.0159
Garrison Run	GR 1	June 13, 2011	42.1409	-80.07223

Return to Page 2

Table 2. IBI scoring criteria for streams of the Presque Isle Bay watershed (Pyron *et al.2004)*

Category	Metric	Scoring Criteria		
		1	3	5
Species Richness and Composition	1. Total number of species	< 2	2-3	> 3
	2. Number of darter/sculpin species	< 1	1-2	> 2
	3. Headwater species	< 2	2-3	> 3
	4. Number of minnow species	< 2	2-4	> 4
	5. Number of sensitive species	< 1	1-2	> 2
	6. Percent tolerant species	> 57%	34-57%	< 34%
	7. Simple lithophil species	< 1.5	1.5-3	> 3
Trophic Composition	8. Percent pioneering species	> 55%	30-55%	< 30%
	9. Percent omnivores	> 20%	10-20%	< 10%
	10. Percent insectivores	< 14%	14-26%	> 26%
Fish Abundance and Composition	11. % DELT anomalies	> 1.3	0.1-1.3	< 0.1
	12. Fish numbers	< 50	51-110	> 110

Return to Page 3

Table 3. IBI classification (Karr *et al.1986)*

IBI Score	Class	Attributes
58 - 60	Excellent (E)	Comparable to the best situations without human disturbance; all regionally expected species for the habitat and stream size, including the most tolerant forms are present with a full array of age classes; balance trophic structure
53 - 57	E-G	
48 - 52	Good (G)	Species richness somewhat below expectations, especially due to the loss of the most intolerant forms; some species are present with less than optimal abundances or size distributions; trophic structure shows some signs of stress.
45 - 47	G-F	
40 - 44	Fair (F)	Signs of additional deterioration include loss of intolerant forms, fewer species, highly skewed trophic structure; older age classes of top predators may be rare.
35 - 39	F-P	
28 - 34	Poor (P)	Dominated by omnivores, tolerant forms, and habitat generalists; few top carnivores; growth rates and condition factors commonly depressed; diseased fish often present.
23 - 27	P-VP	
12 - 22	Very Poor (VP)	Few fish present, mostly introduced or tolerant forms; disease, parasites, fin damage, and anomalies regular.
	No Fish	Sampling finds no fish

Return to Page 3

Table 4. Presque Isle Bay tributary fish community data (2011)

Species		Site													
		SR1	CC1	CC2	CC4	CC6	MC1	MC3	MC4	MC5	MC6	MC8	GR1	Total	Percent
Family *Cyprinidae*															
Blacknose Dace	*Rhinichthys obtusus*	0	11	126	31	60	87	48	33	143	646	164	19	1368	50.22
Central Stoneroller	*Campostoma anomalum*	0	0	0	0	0	1	9	0	27	175	1	55	268	9.84
Creek Chub	*Semotilus atromaculatus*	0	26	117	160	211	121	11	28	43	15	74	6	812	29.81
Emerald Shiner	*Notropis atherinoides*	0	1	0	0	0	0	0	0	0	0	0	0	1	0.04
Goldfish	*Carassius auratus*	0	0	0	0	0	1	0	0	0	0	0	0	1	0.04
Longnose Dace	*Rhinichthys cataractae*	0	0	0	0	0	2	0	0	0	0	0	0	2	0.07
Spottail Shiner	*Notropis hudsonius*	0	5	0	0	0	0	0	0	0	0	0	0	5	0.18
Family *Centrarchidae*															
Bluegill	*Lepomis macrochirus*	0	1	0	0	0	0	1	0	0	2	0	0	4	0.15
Pumpkinseed	*Lepomis gibbosus*	0	0	0	0	0	1	0	0	0	1	0	0	2	0.07
Rock Bass	*Ambloplites rupestris*	0	20	0	0	0	0	0	0	0	0	0	0	20	0.73
Family *Ictaluridae*															
Brown Bullhead	*Ameiurus nebulosus*	1	7	0	0	0	0	0	0	0	0	0	0	8	0.29
Yellow Bullhead	*Ameiurus natalis*	0	1	0	0	0	0	0	0	0	0	0	0	1	0.04
Family *Percidae*															
Logperch	*Percina caprodes*	0	1	0	0	0	0	0	0	0	0	0	0	1	0.04
Rainbow Darter	*Etheostoma caeruleum*	0	0	0	0	0	4	0	0	0	59	3	0	66	2.42
Family *Cottidae*															
Mottled Sculpin	*Cottus bairdi*	0	0	0	0	0	12	9	0	9	34	10	3	77	2.83
Family *Salmonidae*															
Rainbow Trout	*Oncorhynchus mykiss*	13	10	0	0	0	0	0	0	0	0	0	0	23	0.84
Family *Catostomidae*															
White Sucker	*Catostomus commersoni*	0	2	0	0	0	10	8	0	11	16	18	0	65	2.39
Total Number of Fish		14	85	243	191	271	239	86	61	233	948	270	83	2724	
Number of Species		2	11	2	2	2	9	6	2	5	8	6	4	17	

Return to Page 3

Table 5. Presque Isle Bay tributary fish community data (2001) (Pyron *et al. 2004)*

Species		Site													
		SR1	CC1	CC2	CC4	CC6	MC1	MC3	MC4	MC5	MC6	MC8	GR1	Total	Percent
Family *Cyprinidae*															
Blacknose Dace	*Rhinichthys obtusus*	0	0	16	50	0	28	12	15	86	21	52	0	280	31.50
Bluntnose Minnow	*Pimephales notatus*	2	4	0	0	0	0	0	0	0	0	0	0	6	0.67
Central Stoneroller	*Campostoma anomalum*	0	0	0	0	0	9	8	0	19	1	1	0	38	4.27
Creek Chub	*Semotilus atromaculatus*	17	4	87	63	35	90	8	27	35	3	38	0	407	45.78
Fathead Minnow	*Pimephales promelas*	0	0	0	0	0	1	0	0	0	0	0	0	1	0.11
Family *Centrarchidae*															
Bluegill	*Lepomis macrochirus*	0	1	0	0	0	0	0	0	0	0	0	0	1	0.11
Pumpkinseed	*Lepomis gibbosus*	0	6	0	0	0	0	0	0	0	0	0	0	6	0.67
Rock Bass	*Ambloplites rupestris*	0	6	0	0	0	0	0	0	0	0	0	0	6	0.67
Family *Percidae*															
Rainbow Darter	*Etheostoma caeruleum*	0	0	0	0	0	1	0	0	9	7	2	0	19	2.14
Yellow Perch	*Perca Flavescens*	0	1	0	0	0	0	0	0	0	0	0	0	1	0.11
Family *Cottidae*															
Mottled Sculpin	*Cottus bairdi*	0	0	0	0	0	5	0	0	2	1	15	0	23	2.59
Family *Catostomidae*															
White Sucker	*Catostomus commersoni*	0	0	0	0	0	65	14	0	17	2	2	0	100	11.25
Family *Gottidae*															
Round Goby	*Neogobius melanostomus*	0	1	0	0	0	0	0	0	0	0	0	0	1	0.11
Total Number of Fish		19	23	103	113	35	199	42	42	168	35	110	0	889	
Number of Species		2	7	2	2	1	7	4	2	6	6	6	0	13	

Return to Page 3

Table 6. Species richness and total fish numbers: 2001 and 2011

		Site												
		SR1	CC1	CC2	CC4	CC6	MC1	MC3	MC4	MC5	MC6	MC8	GR1	Total
Species Richness	*2001*	2	7	2	2	1	7	4	2	**6**	6	6	0	13
	2011	2	**11**	2	2	**2**	**9**	**6**	2	5	**8**	6	**4**	**17**
Number of Individuals	*2001*	**19**	23	103	113	35	199	42	42	168	35	110	0	889
	2011	14	**85**	**243**	**191**	**271**	**239**	**86**	**61**	**233**	**948**	**270**	**83**	**2724**

Return to Page 3

Table 7. Species observed: 2001 and 2011

Species		Year*	
		2001	2011
Blacknose Dace	*Rhinichthys obtusus*	X	X
Bluegill	*Lepomis macrochirus*	X	X
Bluntnose Minnow	*Pimephales notatus*	X	
Brown Bullhead	*Ameiurus nebulosus*		X
Central Stoneroller	*Campostoma anomalum*	X	X
Creek Chub	*Semotilus atromaculatus*	X	X
Emerald Shiner	*Notropis atherinoides*		X
Fathead Minnow	*Pimephales promelas*	X	
Goldfish	*Carassius auratus*		X
Logperch	*Percina caprodes*		X
Longnose Dace	*Rhinichthys cataractae*		X
Mottled Sculpin	*Cottus bairdi*	X	X
Pumpkinseed	*Lepomis gibbosus*	X	X
Rainbow Darter	*Etheostoma caeruleum*	X	X
Rainbow Trout	*Oncorhynchus mykiss*		X
Rock Bass	*Ambloplites rupestris*	X	X
Round Goby	*Neogobius melanostomus*	X	
Spottail Shiner	*Notropis hudsonius*		X
White Sucker	*Catostomus commersoni*	X	X
Yellow Bullhead	*Ameiurus natalis*		X
Yellow Perch	*Perca Flavescens*	X	

*X = present

Return to Page 4

Table 8. Index of biotic integrity scores (2011)

Metric	Score											
	SR1	CC1	CC2	CC4	CC6	MC1	MC3	MC4	MC5	MC6	MC8	GR1
1. Total number of species	3	5	3	3	3	5	5	3	5	5	5	5
2. Number of darter/sculpin species	1	3	1	1	1	3	3	1	3	3	3	3
3. Headwater species	1	1	1	1	1	3	3	1	3	3	3	3
4. Number of minnow species	1	3	3	3	3	5	3	3	3	3	3	3
5. Number of sensitive species	3	3	1	1	1	5	3	1	3	3	3	3
6. Percent tolerant species	5	3	1	1	1	1	1	1	1	1	1	1
7. Percent pioneering species	5	3	3	1	1	3	5	3	3	5	5	1
8. Percent omnivores	5	1	1	1	1	1	1	1	1	1	1	1
9. Percent insectivores	1	3	1	1	1	1	1	1	1	1	1	1
10. Simple lithophil species	1	5	1	1	1	3	3	1	3	3	3	1
11. % DELT anomalies	5	5	5	5	5	5	5	5	5	5	3	5
12. Fish numbers	1	3	5	5	5	5	3	3	5	5	5	3
IBI Score (2011)	32	38	26	24	24	40	36	24	36	38	36	30
Class*	NA	NA	NA	NA	NA	A	NA	NA	NA	NA	NA	NA
Class**	P	F-P	P-VP	P-VP	P-VP	F	F-P	P-VP	F-P	F-P	F-P	P

* Yoder (1995): NA = non-attaining; A = attaining

** Karr (1981) and Karr *et al. (1986): F = fair; F-P = fair-poor; P = poor; P-VP = poor-very poor*

Return to Page 4

Table 9. Fish classifications used for calculating index of biotic integrity (2011)

	Classification*								
Species	Darter/Sculpin	Headwater	Minnow	Sensitive	Tolerant	Pioneer	Omniovore	Insectivore	Lithophil
Blacknose Dace		X	X		X		X		X
Central Stoneroller			X		X	X			
Creek Chub			X		X	X	X		
Emerald Shiner			X					X	X
Goldfish			X		X		X		
Longnose Dace			X	X				X	
Spottail Shiner			X	X				X	
Bluegill					X			X	
Pumpkinseed								X	
Rock Bass									
Brown Bullhead					X			X	
Yellow Bullhead					X			X	
Logperch	X							X	X
Rainbow Darter	X			X				X	X
Mottled Sculpin	X	X		X				X	
Rainbow Trout				X					
White Sucker					X		X		X

* Classficiations were dervied from Ohio EPA (1987), Simon (1991), and Barbour *et al. (1999)*

Return to Page 4

Table 10. Index of biotic integrity scores (2001)

Metric	Score											
	SR1	CC1	CC2	CC4	CC6	MC1	MC3	MC4	MC5	MC6	MC8	GR1
1. Total number of species	3	5	3	3	1	5	5	3	5	5	5	ND
2. Number of darter/sculpin species	1	1	1	1	1	3	1	1	3	3	3	ND
3. Headwater species	1	1	1	1	1	3	1	1	3	3	3	ND
4. Number of minnow species	3	3	3	3	1	3	3	3	3	3	3	ND
5. Number of sensitive species	1	1	1	1	1	3	1	1	3	3	3	ND
6. Percent tolerant species	1	3	1	1	1	1	1	1	1	1	1	ND
7. Percent pioneering species	1	3	1	1	1	3	3	1	3	5	3	ND
8. Percent omnivores	1	1	1	1	1	1	1	1	1	1	1	ND
9. Percent insectivores	1	5	1	1	1	1	1	1	1	3	3	ND
10. Simple lithophil species	1	1	1	1	1	3	3	1	3	3	3	ND
11. % DELT anomalies	5	5	5	5	5	5	5	5	5	5	5	ND
12. Fish numbers	1	1	3	5	1	5	1	1	5	1	3	ND
IBI Score (2001)	20	30	22	24	16	36	26	20	36	36	36	ND
Class*	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Class**	VP	P	VP	P-VP	VP	F-P	P-VP	VP	F-P	F-P	F-P	No Fish

* Yoder (1995): NA = non-attaining; A = attaining

** Karr (1981) and Karr *et al. (1986): F-P = fair-poor; P = poor; P-VP = poor-very poor; VP = very poor*

Return to Page 4

Table 11. Fish classifications used for calculating index of biotic integrity (2001)

	Classification*								
Species	Darter/Sculpin	Headwater	Minnow	Sensitive	Tolerant	Pioneer	Omniovore	Insectivore	Lithophil
Blacknose Dace		X	X		X		X		X
Bluntnose Minnow			X		X	X	X		
Central Stoneroller			X		X	X			
Creek Chub			X		X	X	X		
Fathead Minnow			X		X	X	X		
Bluegill					X			X	
Pumpkinseed								X	
Rock Bass									
Rainbow Darter	X			X				X	X
Yellow Perch								X	
Mottled Sculpin	X	X		X				X	
White Sucker					X		X		X
Round Goby									

* Classficiations were dervied from Ohio EPA (1987), Simon (1991), and Barbour *et al. (1999)*

Return to Page 4

Table 12. Index of biotic integrity scores (2011 and 2001)

Metric	Score											
	SR1	CC1	CC2	CC4	CC6	MC1	MC3	MC4	MC5	MC6	MC8	GR1
IBI Score (2011)	**32**	**38**	**26**	24	**24**	**40**	**36**	**24**	36	**38**	36	**30**
Class*	NA	NA	NA	NA	NA	A	NA	NA	NA	NA	NA	NA
Class**	P	F-P	P-VP	P-VP	P-VP	F	F-P	P-VP	F-P	F-P	F-P	P
IBI Score (2001)	20	30	22	24	16	36	26	20	36	36	36	No Fish
Class*	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Class**	VP	P	VP	P-VP	VP	F-P	P-VP	VP	F-P	F-P	F-P	No Fish

* Yoder (1995): NA = non-attaining; A = attaining

** Karr (1981) and Karr *et al. (1986): F = fair; F-P = fair-poor; P = poor; P-VP = poor-very poor; VP = very poor*

Return to Page 4

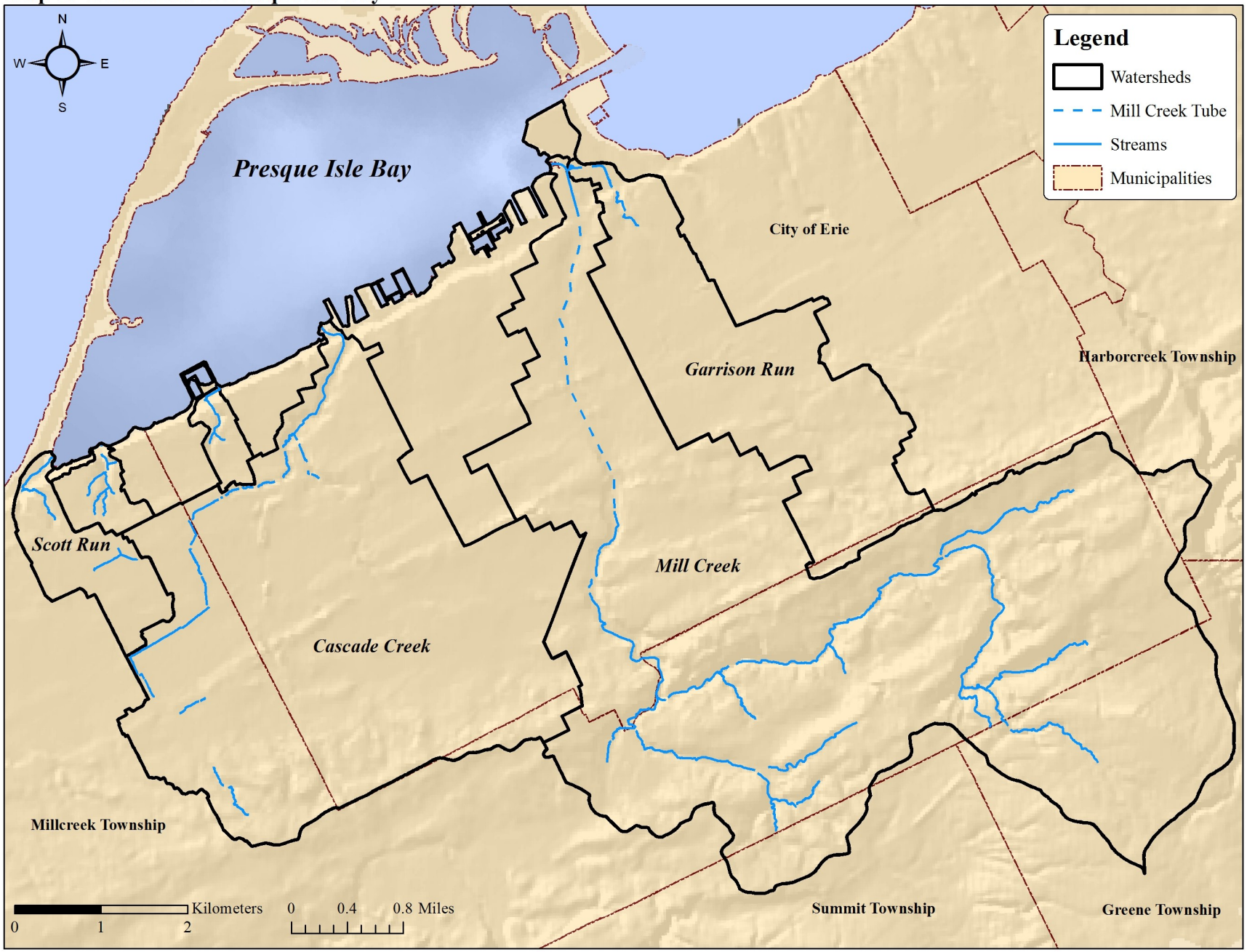
Table 13. Water quality and site data (2011)

Metric	Result											
	SR1	CC1	CC2	CC4	CC6	MC1	MC3	MC4	MC5	MC6	MC8	GR1
Temperature (°C)	14.85	19.38	16.05	15.59	14.86	15.15	15.02	14.75	15.01	15.95	14.24	13.73
Temperature (°F)	58.73	66.88	60.89	60.06	58.75	59.27	59.04	58.55	59.02	60.71	57.63	56.71
Specific Conductance (µS cm^{-1})	1,290	1,229	1,223	1,600	1,680	598	604	525	581	536	616	1,450
Dissolved Oxygen (mg L^{-1})	7.73	7.61	7.40	7.49	6.52	7.84	8.29	5.86	8.28	8.25	7.57	7.67
pH	8.51	8.75	8.43	8.36	7.95	8.79	8.83	8.25	8.71	8.15	8.33	8.32
Stream Depth (centimeters)	7.6	18.0	22.9	22.9	15.0	14.2	10.7	7.1	9.1	13.5	9.1	34.3
Stream Depth (inches)	3.0	7.1	9.0	9.0	5.9	5.6	4.2	2.8	3.6	5.3	3.6	13.5
Stream Width (meters)	2.8	7.4	6.9	5.3	2.3	12.6	7.2	1.5	8.6	3.8	4.6	6.3
Stream Width (feet)	9.28	24.28	22.58	17.40	7.47	41.20	23.75	5.00	28.16	12.50	15.04	20.75

Return to Page 4

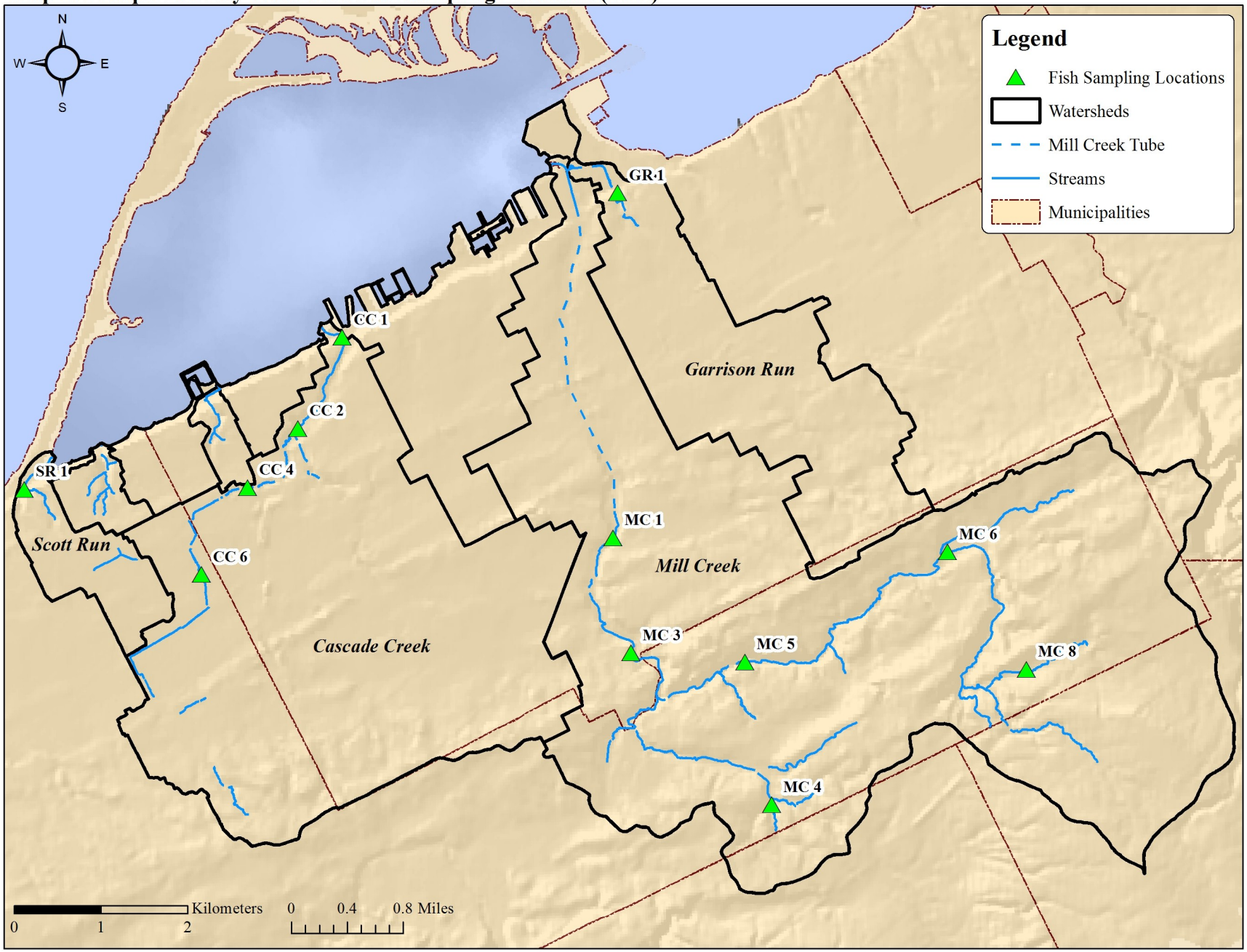
APPENDIX D: MAPS

Map 1: Tributaries of Presque Isle Bay



Return to Page 1

Map 2: Presque Isle Bay Watershed Fish Sampling Locations (2011)



Return to Page 2