2.7 Wetland Macrophyte Index

2.7.1 What is measured?

The average Wetland Macrophyte Index (WMI) score of each region. This coastal wetland indicator provides a surrogate for wetland water quality and consequently the level of human impact; wetland macrophytes are directly influenced by water quality and impairment in wetland quality can be reflected by taxonomic composition of the aquatic plant community (Croft and Chow-Fraser, 2007).

2.7.2 How is it measured?

The WMI uses aquatic plants as an indicator of water quality. The WMI directly links the presence of certain groups of plants to the degree of human disturbance. Individual species are ranked based on their tolerance to degradation and their niche breadth. Based on the species composition in a wetland, these scores are tallied and an overall WMI score is calculated for a wetland.

The WMI score of a wetland can range from 1 to 5, based on the presence of plants in the various groups. In general, a low score (1 or 2) indicates the presence of certain plant taxa that are tolerant of high levels of human disturbance (i.e. excess nutrients and low water clarity) and a high score (4 or 5) of taxa that are intolerant of human disturbance. Wetlands with WMI scores below 2.5 can be considered impaired (moderately to highly degraded conditions) and may require restoration and other management interventions. Wetlands with WMI scores above 3.5 usually mean that the wetland is in good condition. To date, the maximum WMI score recorded was 4.10. This was found in Tadenac Bay, a fish and wildlife sanctuary in eastern Georgian Bay, which has been managed with minimal human disturbance since the late 1900s (Croft and Chow-Fraser, 2007).

2.7.3 Why is it important?

Aquatic Vegetation

Coastal marshes contain both terrestrial (on shore) and aquatic vegetation, which are plants that thrive in a flooded environment. This latter group is also called aquatic macrophytes and they dominate coastal marshes, providing habitat structure that facilitates many of the ecosystem services discussed above (Section 2.6.3). In aquatic ecosystems, macrophytes, along with algae, are the primary producers. They trap the sun's energy and make it available for other species. Macrophytes have developed special adaptations to living in wetlands that are prone to both draw-down and flooding. Unlike most terrestrial vegetation primarily relies on sexual reproduction, aquatic macrophytes typically reproduce asexually from plant fragments or parts of their rhizomes (Sawada et al. 2003). They also form overwintering buds, called turions, which sink to the bottom when the water freezes, and are capable of surviving droughts and low temperatures before rising again in the spring. Some remain in the wetland until favourable conditions return, and other colonize distant habitats by floating in currents or hitching a ride on boats, birds, and mammals. This is one reason that alien invasive macrophytes are difficult to eradicate once they become established in the Great Lakes (Midwood et al., 2011).

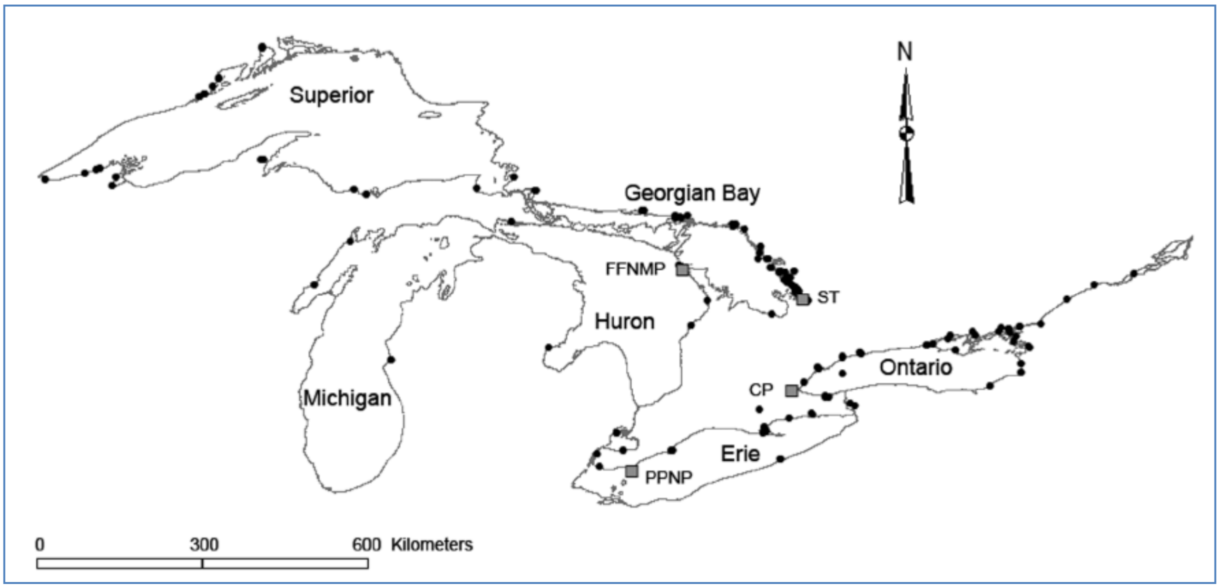
Relationship between the Wetland Quality Index (WQI) and Wetland Macrophyte Index

Wetland degradation in the Great Lakes basin has been attributed to a variety of human disturbances, including increased loading of nutrients and sediment from agricultural and urban development, introduction of invasive species, and shoreline development and recreational activities. The extent to which these factors contribute to marsh degradation depends on the type of wetland. For example, coastal marshes located at the mouth of rivers and estuaries are susceptible to altered land uses in their watersheds, and many in Lakes Ontario and Erie have become turbid, eutrophic systems limiting species composition of submergent macrophytes (Lougheed et al. 2001, McNair and Chow-Fraser 2003). Changes in the submergent community are known to affect communities of zooplankton, benthic invertebrates, and fish. Because water clarity and nutrient levels in coastal marshes have overriding influence on subsequent trophic levels, Chow-Fraser (2006) developed the water quality index (WQI) to measure the degree of degradation attributable to human activities. This index includes six categories that range from highly degraded (index score of –3) to excellent (index score of +3) and has been used successfully to rank 110 wetlands throughout the Great Lakes shoreline according to their degree of water quality impairment (Chow-Fraser, 2006). Cvetkovic and Chow-Fraser (2011) conducted a survey throughout the Great Lakes and found that coastal wetlands in eastern Georgian Bay have the best water-quality conditions, indicating that they have not been negatively impacted by human activities (Figure 39).

Despite the effectiveness of the WQI as a monitoring tool, the effort and costs required to measure all 12 water quality parameters (i.e., physical characteristics, various forms of major nutrients, suspended solids, and chlorophyll concentrations), renders it unlikely to be adopted by most environmental agencies and/or used as a public monitoring protocol (Midwood et al., 2011). Therefore Croft and Chow-Fraser developed the WMI in 2007 to provide a more cost effective and public friendly monitoring tool. Using plants (macrophytes) as a biotic indicator has a number of advantages. First, because wetland plants are essentially non-motile, their distribution can be georeferenced on each sampling occasion and changes in distribution can be tracked over time. Second, compared with fish surveys that require either an electrofishing boat or series of paired fyke nets, plant surveys can be accomplished without specialized and expensive equipment, and with only one or two trained personnel in waders and/or a canoe. Unlike fish and zoobenthos surveys that require overnight traps, most plant surveys can be completed in a day. Additionally, results are available immediately with limited need for further processing such as surveys for macroinvertebrates, zooplankton, or periphyton (Croft and Chow-Fraser, 2007).

The methodology for the development of the WMI is based on previous papers that relate zooplankton and fish to environmental variables using canonical correspondence analysis (CCA). The use of CCA to develop plant indices is prevalent in Europe (e.g., Dodkins et al. 2005), but has not been widely used in North America. The WMI assumes aquatic plants (all species growing obligately in flooded areas but excluding those typically associated with wet meadows) will respond directly (through competition for light and nutrients) or indirectly (through food-web interactions) to changes in water quality conditions. Croft and Chow-Fraser (2007) showed that response to the degree of water quality impairment is reflected in the taxonomic composition of the aquatic plant community. They validated the WMI by choosing two sites that have undergone rehabilitation as part of a Great Lakes remedial action plan (RAP) program (Cootes Paradise Marsh in the Hamilton Harbour RAP and Sturgeon Bay in the Severn Sound RAP, [Hartig 1993]), and for which there exist plant species lists corresponding to conditions before and after RAP initiatives. Two national parks were used as case studies to demonstrate the usefulness of the WMI in routine monitoring (Croft and Chow-Fraser, 2007).

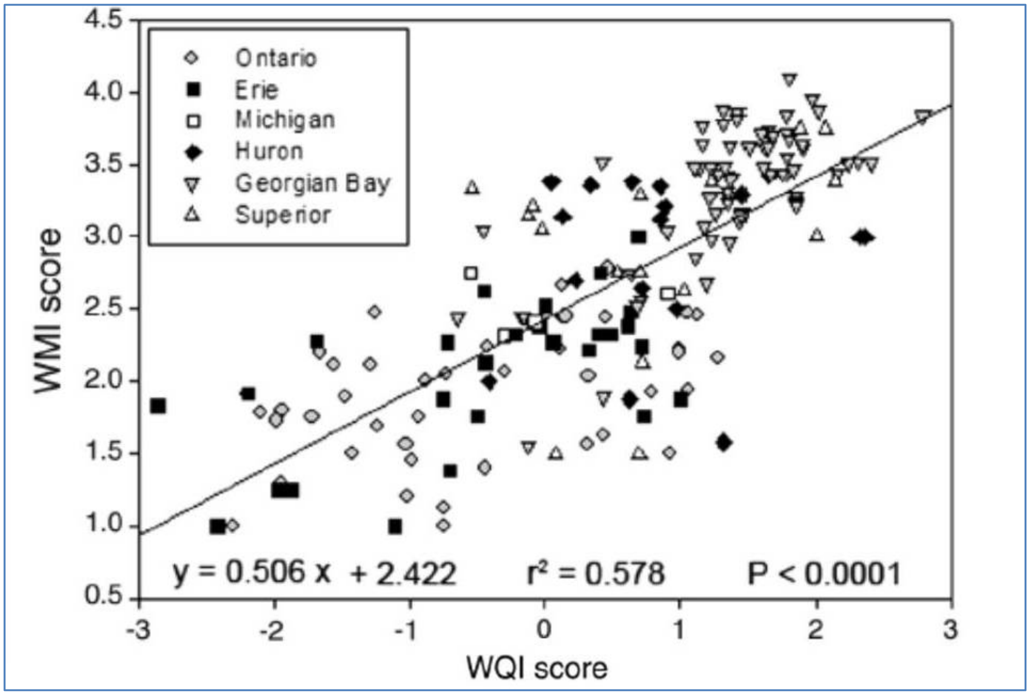
To quantify the extent to which WMI scores accurately reflected water quality conditions, Croft and Chow-Fraser (2007) regressed the WMI scores against corresponding WQI scores for 176 wetland-years (Figure 37) from their large database that had both water quality and plant information (Figure 38). They found a highly significant linear relationship between the two indices (r2 = 0.57, P < 0.01), indicating good correspondence between the presence/absence of plants and water quality conditions.



Location of the four study sites used for validation of the WMI are indicated by square symbols: FFNMP = Fathom Five National Marine Park, ST = Sturgeon Bay, CP = Cootes Paradise, and PPNP = Point Pelee National Park.

Source: Croft and Chow-Fraser, 2007.

Figure 37: Location of 176 wetland years used in the application of the WMI

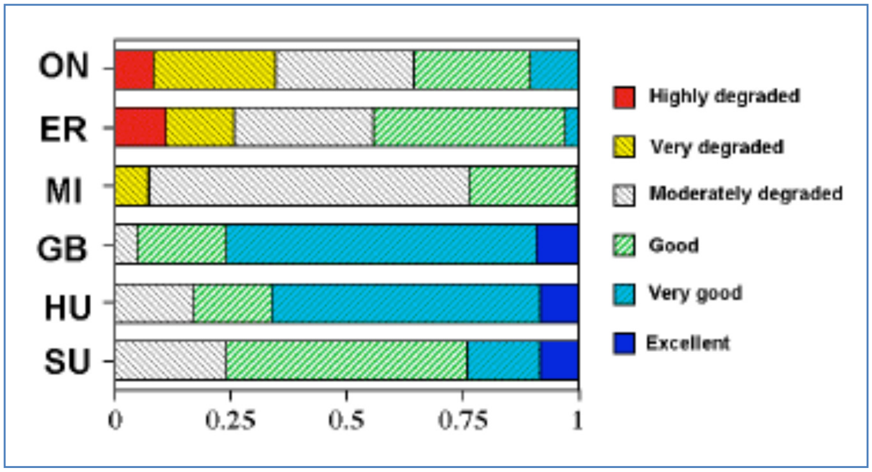


Source: Croft and Chow-Fraser, 2007.

Figure 38: Relationship between the WMI score and WQI score for 176 wetland-years grouped by lake

Factors Influencing Coastal Wetland Quality

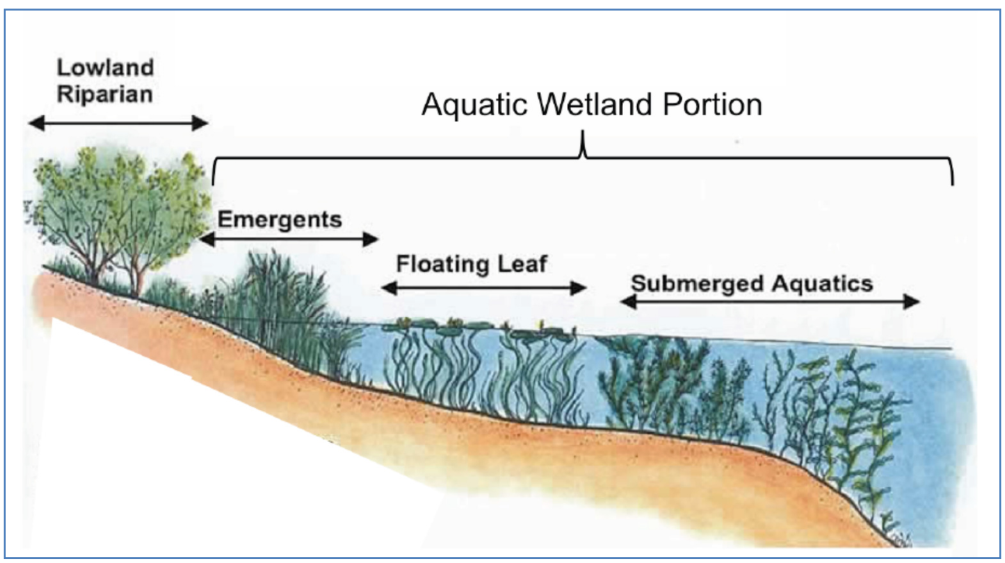
Cvetkovic and Chow-Fraser (2011) found that wetlands in Georgian Bay are some of the most pristine in the entire Great Lakes (Figure 39) and contain some of the greatest diversity of fish (Seilheimer and Chow-Fraser, 2007) and vegetation (Croft and Chow-Fraser 2007). This is largely due to limited human access to the Georgian Bay region and the mainly seasonal, recreational usage. Currently, the major threat to Georgian Bay coastal wetlands is changes to the natural water-level region and the forecasted future continuation of low water levels due to global climate change (Midwood et al., 2011).



Source: Chow-Fraser, Date unknown.

Figure 39: Wetland water quality scores among the Great Lakes

Coastal wetlands are dynamic systems, where a diversity of terrestrial and aquatic biota has alternated their dominance according to the natural 7-10 year cycles of water-level fluctuations in the Great Lakes. In years of high water, terrestrial vegetation dies back, and in years of low water levels, aquatic vegetation disappears (Keddy and Reznicek 1986; Figure 40). Without inter-annual water-level variation, either the aquatic or the terrestrial vegetation would dominate at the expense of the other. Since 1999, water levels in Lake Huron have been low and record lows were recorded in 2012. This stasis in water level has allowed terrestrial vegetation to move into coastal wetlands and there has been a net loss of aquatic habitat (Midwood and Chow-Fraser, 2012).



Source: www.aquatichabitat.ca

Figure 40: Common distribution of wetland plants in a coastal wetland. As water levels change, the plant community will shift in response.

Coastal wetlands of the Great Lakes exist at the interface between the terrestrial and aquatic ecosystems. Hydrologically connected either seasonally or permanently, these shallow marshes have diverse emergent and submergent vegetation that provide important spawning habitat for many species of the Great Lakes fish community (Jude and Pappas 1992).

There is well-documented evidence that land-use alteration in the watersheds of coastal wetlands can negatively affect their habitat quality (Crosbie and Chow-Fraser, 1999; Lougheed et al., 2001; Chow-Fraser, 2006). Agricultural and urban development is generally accompanied by a high nutrient and sediment load to the wetlands, leading to high algal production and increased water turbidity. These changes can cause an overall decrease in macrophyte abundance and diversity (Chow-Fraser et al., 1998). Submergent vegetation is crucial for piscivores (e.g., largemouth bass, *Micropterus salmoides*; northern pike, *Esox lucius*) and forage species (e.g., yellow perch, *Perca flavescens*; sunfish, *Lepomis* sp.; and cyprinids) because it provides structure for spawning, refugia for larvae and juveniles, and habitat for benthic and planktonic prey (Casselman and Lewis, 1996). The plants can also provide shade, reducing local temperature and making it suitable for many cool-water species. Any anthropogenic factor that degrades the overall habitat quality in coastal wetlands can cause a shift in the fishes toward more pollution-tolerant and less desirable assemblages (Brazner and Beals, 1997).

2.7.4 What do the grades mean?

The Wetland Macrophyte Index grades are:

- A > 3.75
- B 3.74 – 3.50
- C 3.49 – 2.50
- D – does not apply
- F < 2.50

The grading system was developed in consultation with Dr Pat Chow-Fraser of McMaster University. As discussed in Section 2.7.2 above, the WMI score of a wetland can range from 1 to 5. Wetlands with WMI scores below 2.5 can be considered impaired (moderately to highly degraded conditions) and may require restoration and other management interventions. Wetlands with WMI scores above 3.5 usually mean that the wetland is in good condition. While a score of 5 is the high end of the scale, a wetland will never record this value given that lower scores are provided for generalist species that are also found in pristine wetlands. To date, the maximum WMI score recorded was 4.10. This was found in Tadenac Bay, a fish and wildlife sanctuary in eastern Georgian Bay, which has been managed with minimal human disturbance since the late 1900s.

2.7.5 What are the results?

Table 11: Grades for WMI

Region Name	Average WMI Score	Grade
McGregor Bay & Killarney	3.27	C
French River	3.65	B
Britt	3.58	B
Pointe au Baril	3.52	B
Carling	3.64	B
Parry Sound	No data	-
Massasauga & Sans Souci	3.54	B
Twelve Mile Bay & Go Home Bay	3.71	B
Cognashene	3.76	A
Honey Harbour	3.34	C
State of the Bay 2013 Average	3.56	B