

Assessment of shoreline habitats in the Kalman Preserve, Emmet County, MI

Julia Mantey
Rivers, Lakes and Wetlands
University of Michigan Biological Station
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Abstract

Great lakes wetlands are important habitats for fish and other biota. They are important to the lifecycles of many floral and faunal species that are ultimately crucial to food webs in other ecosystems. The Kalman Preserve is owned by the Little Traverse Conservancy and contains wetland habitats on the shore of the Little Traverse Bay in Emmet County, MI. In 2006 a group of University of Michigan students found that the preserve, which includes cedar swamp, marsh, interdunal and shoreline sections, had a Floristic Quality Index value of 61.7, which indicates that the protected area holds an extremely rare level of pre-European characteristics. When they evaluated the interdunal and shoreline area alone, the value was considerably lower, which suggests degradation of this wetland habitat. We evaluated the same interdunal/shoreline subregion of the preserve using the Wetland Fish Index (WFI_{Basin}) to assess its quality as a fish habitat. Our results suggest that the shoreline and inshore pond are facultative habitats. Evaluation of the bay and pond together yielded a higher index value than evaluation of the bay alone, and a lower index value than the pond alone. Our findings reinforce the importance of protecting the bay, pond, and surrounding area in maintaining the extremely rare quality of the preserve.

Introduction

The amount of Great Lakes shoreline established as wetland habitat has drastically declined since European settlement of the Great Lakes basin. Direct and indirect human alteration of the coastlines continues to change available habitat, often, if not always, resulting in its degradation. Anthropogenic factors such as nutrient loading, pollution, and alteration of coastline and waterways all contribute to the degradation of wetlands (Brazner 1997).

Wetland ecosystems are closely interconnected to surrounding aquatic and terrestrial ecosystems. Wetlands serve a variety of functions. They are able to absorb and recycle nutrients in water and groundwater and buffer pollutants that might otherwise cause eutrophication. They retain water and catch sediments and organic matter and maintain very high metabolic intensity, without which pelagic metabolism might be significantly altered (Wetzel 1992). Wetlands also serve as spawning areas and nurseries to young-of-year fishes, including sport fishes that are important to recreation. Macroinvertebrates and amphibians are also known to utilize wetlands for some or all of their life cycles. Fish, birds, and mammals feed on primary consumers found in wetlands; the macrophyte communities of wetland habitats are thus important because they are the bases of numerous food webs (Jude and Pappas 1992).

The U.S. Fish and Wildlife Service defines wetlands as transitional lands between aquatic and terrestrial systems where the water table is usually at, near, or just above the land. Wetlands are identified as areas that support hydrophytes, and/or have primarily undrained, hydric soils or nonsoil, saturated or flooded substrate (Cowardin, *et al.* 1979). Fishes generally prefer wetlands over other habitats (Wei, *et al.* 2004). Wetlands are often areas of high primary productivity, which provides a rich food source of zooplankton and benthic species for fishes. Wetlands are also warm and provide shelter from any harsh wave conditions in the larger body of water (Jude and Pappas 1992).

With the decline of available wetlands in the Great Lakes region and concurrent advancements in modern ecological assessment technology, public awareness and concern regarding the maintenance of aquatic systems has increased (Seilheimer *et al.* 2007). A necessary part of realizing conservation and ecologically responsible management of our wetlands is to identify an index by which wetland quality can be easily and accurately assessed. With an effective index, wetland managers can quickly assess and then continue to regularly monitor these systems (Uzarski, *et al.* 2007).

Within the past two decades, a variety of wetland indices based on different wetland factors have been developed, revisited and revised. Examples include indices based on water quality (Chow-Fraser 2006), macrophytes (Croft and Chow-Fraser 2007), and other biotic populations. The recently released 2008 Great Lakes Coastal Wetland Monitoring Plan identifies indices based on a wide variety of abiotic and biotic wetland characteristics, all of which may be used to evaluate and monitor wetland quality. The Plan recommends use of the Floristic Quality Assessment for macrophyte-based evaluations, and use of the fish-based Index of Biotic Integrity (IBI) for evaluations based on fish populations (Uzarski, *et al.* 2008).

In lieu of the fish-based IBI, which calls for more elaborate testing and is limited by its specificity to only two plant zones, our study used the Wetland Fish Index (WFI_{Basin})

developed in 2007 by Seilheimer and Chow-Fraser to assess wetland quality (Uzarski, et al. 2008, Seilheimer and Chow-Fraser 2007).

The goal of our study was to evaluate an area of Lake Michigan coastal wetland that falls within the Kalman Nature Preserve. The preserve is located on the Little Traverse Bay and owned by the Little Traverse Conservancy. It was assessed in 2006 by students of the University of Michigan Biological Station (UMBS) using the Floristic Quality Index (FQI) as prescribed by the Michigan Department of Natural Resources. The FQI is calculated with values assigned using the FQA described in the current Great Lakes Coastal Wetland Monitoring Plan (Albert 2008)

The 2006 study found that the region covered by the preserve had an FQI value of 61.7, which qualifies the preserve as an extremely rare habitat containing a valuable proportion of native flora. The UMBS group also separately evaluated three subhabitat systems they observed within the preserve: a cedar swamp, a marsh, and an interdunal/shoreline complex. The area referred to as the interdunal/shoreline system in their study contains the two subhabitats (bay and pond) that our July 2008 study focused on. The 2006 FQI evaluation of this subregion found it to be of lower (36.7) score than the overall region protected in the preserve (Baskerville, *et al.* 2006). That the value of this area is comparatively low to the surrounding region suggests that although the habitat is to be considered significant in terms of floristic richness, it may be degraded (Albert 2008).

The objective of our study was to use an alternative index of wetland quality, the Wetland Fish Index (WFI_{Basin}) to evaluate the interdunal/shoreline area based on fishes found in two subhabitats: the shallow waters of the bay and the pond found beyond the first dune. Because our study site was a protected area and WFI scores are minimally affected by inter-annual variations, we could assume that fish communities would not have drastically shifted since 2006 (Seilheimer and Chow-Fraser 2007). We were interested in whether our assessment would yield an evaluation similar to that of the 2006 group. We computed WFI_{Basin} scores for the coastal bay fish habitat and the inland pond that we presume it seasonally interacts with, and also for the sum of both sites. We compute the index in multiple ways possible in order to ensure that our findings were accurate. We also evaluated the two study subregions separately, then calculated their combined score, to investigate their comparative values.

Materials and Methods

Study Site Descriptions

The Little Traverse Conservancy owns the Kalman Nature Preserve. The preserve is located on the shore of the Little Traverse Bay on Lake Michigan, in Emmett County near the city of Harbor Springs. The preserve covers 71 acres of land from the shore of the bay to the Lake Algoma shoreline (Baskerville, et al. 2006). The coastline protected by the preserve is relatively narrow and it is neighbored by residential homes on each side (Figure 1). In our study we sampled from two sites: the shallow waters just offshore, and the heavily vegetated pond that sits close to the shoreline. Based on the abundance of larval fishes we observed in the pond, we assume that its waters interact with the bay with some regularity (Figure 1). We sampled for fishes with one set of traps in the pond and two sets in the bay (see *Quantitative Fish Sampling*).

Aquatic Chemistry Sampling

On the first day of our study, July 21, 2008, we followed the procedure described by Seilheimer and Chow-Fraser (2006) in the development of the original WFI to sample the abiotic characteristics of our two sites. In the bay we sampled in open water at least 10 meters from the edge of any emergent vegetation. In the pond, where there was no open water, we sampled where the water was deepest and submergent vegetation was minimal.

We used the Accumet portable AP61 pH meter and the YSI 30 conductivity meter to measure pH and conductivity, respectively, in the pond and near both sets of traps in the bay. We averaged the two bay measurements for pH and conductivity. We used the Hach HQ 30d flexi dissolved oxygen meter to measure dissolved oxygen in the pond and at a single location in the bay. We assumed that dissolved oxygen levels would not differ significantly between the two sets of traps in the bay.

We also collected water samples in white plastic Nalgene bottles from both sites to be analyzed in the lab for dissolved organic carbon content, Cl^- , chlorophyll a, total phosphorous, total nitrogen, soluble reactive phosphorous, and alkalinity levels. For this sampling we again assumed that chemical properties would be relatively constant throughout the bay area of our study; we took only one set of samples from the bay and one set from the pond.

We measured air and water temperature using an alcohol thermometer on July 21, 23, 26, and 28 and averaged our measurements for both localities.

Quantitative Fish Sampling

We deployed one linear set of five minnow traps spaced 3 meters apart in the pond and two equivalent sets, laid approximately 20 to 30 meters apart, in the bay. We deployed the pond set linearly across the middle of the pond. The average depth of the traps was 56.2 cm. Trap sets in the bay were anchored such that they were perpendicular to the shoreline, and were entirely in open water. The eastern set of traps were deployed at an average depth of 46.4 cm and the western set were at an average depth of 38.6 cm. Fish were collected the 23, 24, 26, and 28 of July. Catch data were recorded as CPUE, where one unit effort equals one set of traps per day to describe species abundances, and one trap per day to describe absolute abundances.

Computations of the WFI_{Basin} and Shannon Diversity Index Scores

We used the WFI_{Basin} formula and associated U and T values assigned to species (Seilheimer and Chow-Fraser 2007) to compute WFI_{Basin} scores by presence/absence (PA) and abundance (AB), with and without correction for exotic species. We computed all four possible scores for the pond and bay separately and for the pond and bay combined, to yield and compare twelve possible scores that could be generated from our data. The WFI_{Basin} (PA) and WFI_{Basin} (AB) formulas are:

$$WFI = \frac{\sum_{i=1}^n Y_i T_i U_i}{\sum_{i=1}^n Y_i T_i}$$

Y_i = presence or log₁₀ abundance (log[x+1] of species I
T_i = value one to three indicating niche breadth
U_i = value one to five indicating tolerance to degradation

We used the Shannon Diversity Index formula to quantify species diversity at each site alone using CPUE values. The formula is:

QuickTime™ and a decompressor are needed to see this picture.

S = number of species
P_i = relative abundance of species i.

Macrophyte Sampling

We used a 1.0 m² quadrat to gather abundance data of macrophytes at each trap along our pond set of traps. To quantify our observations we estimated percent cover and counted stems of species with visible, distinguishable stems.

The same quadrat was used to inventory macrophyte occurrence in the bay, but nine out of ten traps in the bay were in entirely open water. For a more descriptive picture, we also recorded plants observed on the shoreline in addition to the quantitative data we recorded of the species that occurred in our only quadrat that contained macrophytes.

Qualitative Macroinvertebrate Sampling

We sampled qualitatively for macroinvertebrates on July 21. We used dip nets to sample from various microhabitats in the pond. In the bay, where the substrate is rock of various sizes over clay, we were unable to collect any macroinvertebrates using the nets and so collected macroinvertebrates primarily by picking up rocks and using forceps to pick specimens. A few specimens were effectively gathered using nets where there were fewer rocks. Our objective in sampling for macroinvertebrates was simply to gather presence/absence data on the orders found at our sites.

Results

Aquatic Chemistry

We found the pH of both habitats to be circumneutral. Water in the bay (8.62) was slightly more basic than water in the pond (7.63). Conductivity was considerably higher in the pond than in the bay, as were levels of dissolved organic carbon, Cl⁻, total phosphorous, total nitrogen, soluble phosphorous, and alkalinity. Levels of dissolved oxygen and chlorophyll a were found to be higher in the bay. Average temperatures were higher in the pond. (Table 1)

Fish Sampling

In the pond we observed *Umbra limi* in greatest abundance (CPUE). We also observed *Fundulus diaphanus* and *Lepomis macrochirus* in much lower abundance (Figure 2). On the last day of our study we fished for larval specimens and caught young of the year *Umbra limi*, a cyprinid, and *Culaea inconstans* (Table 1).

In the bay the majority of our catch was *Rhynchthys cataractae*, with an average of almost 19 specimens per day, and more than nine specimens per set per day. All other species caught in the bay occurred at relatively low CPUEs (Table 2, Figure 2).

Average abundance per net per day was higher in the bay than in the pond (Figure 3).

Computations of the WFI_{Basin} and Shannon-Weiner Diversity Index Score

Our lowest computed WFI_{Basin} score was obtained for the presence/absence of the bay alone with correction for the presence of exotic species. That score was 2.86, still higher than median score on the index. Our highest score was 3.90, computed for the pond alone and accounting for abundance of each species. All computed scores for the pond were found to be greater than corresponding scores for the combined habitat and for the bay alone. Combined scores were better than bay scores. Scores did not vary much even when adjusted for the presence of exotic species. (Table 3, Figure 4)

We found the Shannon-Weiner Diversity index score to be higher for the bay (3.54) than for the pond (3.45) (Table 4).

Macrophyte Sampling

In the pond the majority of macrophytes occurring were submergent or floating. *Chara*, for example, covered 50 to 100 percent of the substrate across our sampling, and *Brasenia schreberi*, a floating species, covered up to 80 percent of the water's surface in our quadrats. *Schoenoplectus validus* populated the pond's perimeter.

Only *Schoenoplectus americanus* and *Typha x glauca* occurred within our bay quadrat. Various other species were observed along the shoreline (Table 6).

Macroinvertebrate Sampling

We observed a broad diversity of macroinvertebrate species in the pond, and found fewer in the bay. Only two species were unique to the bay: *Unionidae* and *Isopoda*. All other species observed were found occurring in the pond alone or at both sites (Table 7).

Discussion

Our results support the 2006 evaluation of the Kalman Nature Preserve as an important site for conservation and imply the importance of protecting interacting subregions together as a larger unit in order to minimize degradation.

Our results indicate that both the pond and the bay within the Kalman Preserve are valuable Great Lakes coastal wetland habitats. This finding supports the evaluation conducted by previous UMBS students that found the Kalman Preserve to be an extremely rare pre-settlement habitat and its included inderdunal/shoreline wetland area to be of important conservation value (Baskerville, et al. 2006). Our findings may be of value to managers of the Kalman Preserve because they indicate an additional aspect of

its ecological value as a wetland habitat. Our results may also be of value to future researchers interested in using the WFI_{Basin} to evaluate other wetlands, or to future studies regarding the accuracy of this index. The similarity of our evaluation yielded by the WFI_{Basin} to past evaluations of the study site support its validity as a wetland index.

Our multiple analyses of data from the pond and bay alone and pond and bay combined revealed that regardless of the computation method, the pond alone is a higher quality wetland than the bay alone. However, the majority of our catch in the bay was not accounted for in the index because *Rhinichthys cataractae* are not listed in its formula. Given that the species is native, adjustment of the index to account for their presence would likely increase the value of the index. Our computation of the Shannon index supports this theory: when all species in both subhabitats were accounted for, the bay yielded a higher (3.54) diversity score than the pond (3.45). The species' absence in the formula indicates that Seilheimer and Chow-Fraser encountered the species only once or not at all during their entire intensive survey of Great Lakes wetland fish species (Seilheimer and Chow-Fraser 2006). Further studies are needed to identify potential causes of this anomaly.

The comparatively high combined score of the pond and bay and our observations of many larval fishes in the pond imply the importance of protecting inland waters rather than shoreline alone of the Kalman Preserve and elsewhere along the Great Lakes coastline. This finding is not surprising. Uzarski, et al. (2005) found that the most important variable influencing the distribution of fish communities to be plant zonation; the inland pond is full of vegetation whereas the bay was virtually void of macrophytes. The pond also offers other conditions preferred by fish as described by Jude and Pappas (1992): its water was warmer and a beach ridge with plants protected it from any harsh wave conditions that would be found in the bay.

However, the most abundant plant species in the pond was *Chara*, which is identified as a species highly tolerant of nutrient-enriched conditions. According to the 2008 Great Lakes Consortium Great Lakes Coastal Wetland Monitoring Plan, the high density of *Chara* observed in the pond indicates that the habitat may be influenced by degradation from the surrounding areas. This implies the possibility that *Chara* and other highly tolerant species could continually increase in dominance, to the point that the habitat will be less than suitable for native fish species (Albert 2008). The danger suggested by this finding highlights the importance of conserving large areas to minimize degradation and implies the need for continued regular monitoring of subhabitats within the Kalman Preserve.

The 2006 UMBS study of the Kalman Preserve found evidence based in the FQA that the interdunal/shoreline habitat in which our sites were located may be affected by some degree of degradation. Whether or not our 2008 study findings show any increased evidence of degradation is impossible to assess due to our use of entirely different indices; however, our observations of macrophyte relative abundances likewise suggest that the complex is degraded. Regular use of a single index to compare values of our study area over time would be useful to effective management of the preserve in future years.

If the WFI_{Basin} is to be used for monitoring this and other wetlands, *Rhinichthys cataractae* will need to be accounted for in order to yield maximally accurate evaluations and allow for more valid comparisons of the bay and pond subhabitats. In 2004, Wei, et

al. revised Jude and Pappas' (1992) classifications of Great Lakes fishes into three taxonomic groups based on habitat preference. The new classifications developed were "open water," "intermediate," and "wetland." All species found within the Kalman preserve, with the exception of the exotic round goby, are classified by temperature preference and taxocene in the descriptive tables presented in the Wei, et al (2004) study. Longnose dace preferentially inhabit cool, intermediate waters. Consequently it is not surprising that we would find them in the bay, and also understandable that they may not have been observed in the wetland environments studied by Seilheimer and Chow-Fraser. We recommend that the species accounted for in the WFI_{Basin} be expanded to include all species recognized as intermediate by Wei, et al.

In 2007 Cooper, et al. studied the relationship between abundance of round gobies and distance from the Lake Michigan shoreline. The findings suggested that nearshore waters like Lake Algoma may serve as spawning and nursery habitats for *Neogobius melanostomus*, which subsequently disperse into lake and wetland complex habitats (Cooper, et al. 2007). Negative correlations between catch of round gobies and distance of sampling sites from the Lake Michigan shoreline, as we also witnessed in our study, were thought to suggest that coastal wetland habitats (i.e. the Kalman Preserve pond) are more resistant to invasion by *Neogobius melanostomus* than neighboring lacustrine habitats. This may explain why we did not observe any members of this species in the pond habitat, and thus provides an additional reason that the pond habitat should be recognized as highly valuable.

While conducting our study we observed many larval fishes populating the pond habitat. While human activities may not strongly affect larval fish assemblages, alterations of local habitats by direct and indirect human influence can impact such populations (Hook, et al. 2001). Our observation of the Kalman Preserve's likely importance as a nursery for fishes should be investigated with future study because evidence of its use as a nursery habitat would more specifically identify aspects of the pond's ecological value.

Wetlands are important to aquatic, terrestrial, avian, and human populations. Many pollutants that could threaten near-shore and deepwater habitats accumulate in and may be recycled by wetlands. Wetlands tend to be affected first by land-use changes and anthropogenic factors. This makes monitoring of coastal wetlands an optimal method of monitoring for potential threats to larger Great Lakes ecosystems and the entire Great Lakes basin (Uzarski, et al. 2008).

The Great Lakes Coastal Wetland Consortium recommends the use of indices of biotic integrity (IBIs) based on fish, zooplankton, or other biota. Due to the close interrelations between specific fish assemblages and wetland quality, fishes are one multiple biotic groups that serve as good indicator species of wetland health. A number of fish-based IBIs as well as the WFI referenced in our study have historically been developed in reflection of this fact.

Currently the measure of wetland quality based on fishes recommended by the Great Lakes Wetland Consortium is the fish-based IBI (Uzarski 2008). The WFI we used in our study may be a more accurate measure of wetland quality than the fish-based IBI, as the metrics of fish communities the fish-based IBI is based on are not derived from known environmental tolerances of fish species, whereas the WFI qualifies wetlands based on the studied tolerance levels of specific species (Seilheimer and Chow-Fraser,

2007). The presence and relative abundance of highly tolerant fishes can indicate levels of degradation. We assume that the WFI gives at least as accurate a score in comparison to the fish-based IBI because Seilheimer and Chow-Fraser (2006) confirmed that the utility of the WFI is comparable to that of other indices which included a fish-based IBI. The WFI_{Basin} also requires less sampling than the currently prescribed fish-based IBI and can be computed using either presence/absence or abundance data, which makes it a far more time-efficient method of evaluating wetland health. Our findings support the comparable utility of the presence/absence- and abundance-based computations as well as the comparable utility of the index to other, less time-effective indices to evaluate wetland quality.

As need and demand for effective and efficient wetland management increase with the visibility and recognition of anthropogenic effects on Great Lakes ecosystems, an optimally quick and accurate method of quantifying wetland quality is needed. Our study provides evidence that the WFI_{Basin} should be useful in this regard.

Results of our study as well as results of the 2006 FQA by previous UMBS students suggest that the Kalman Preserve interdunal/shoreline area may be degraded by outside influences. This finding demonstrates the need for future regular monitoring of wetland health within the preserve. The WFI_{Basin} is an applicable tested method of evaluation that, with some adjustment to allow for species not accounted for in its development, could potentially be accurately used to that purpose.

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