# Application of the Wetland Fish Index to the Kalman Preserve, Emmet County, Michigan

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**Abstract***:* *The Great Lakes coastal wetlands are important land-water interfaces that serve a variety of functions important to plants and wildlife as well as humans. Human activities such as road building, shoreline development, dredging, draining and land filling contribute to the degradation of these valuable areas. Biological indicators can be used to assess degradation and link potential sources of disturbance. The Wetland fish Index (WFI)(Seilheimer & Chow-Fraser 2006&20078) is a biological index based on fish species composition. Assessing fish species can be cheaper and less time consuming than looking at different parameters of water quality. The index is also able to say more about the long term affects of human disturbances on wetlands as opposed to short term fluxes. We applied the WFI to the Kalman Preserve wetland located on the Little Traverse Bay in Emmet County MI. We found seven different species of fish, a variety of habitats and vegetation, and several groups of macroinvertebrates. The WFI based on fish we caught at the preserve suggested a wetland that is only moderately degraded. These results are in agreement with the past Floristic Quality Assessment conducted in 2006.*

## Introduction:

Lake Michigan wetlands span a surface area of 490km$^2$ (Jude and Pappas 1992) and serve a variety of functions to both humans and wildlife. Wetlands are important for groundwater recharge, sedimentation depositions, flood storage, toxic substance absorption, and nutrient uptake (Herdendorf 1992). Wetlands exist in the terrestrial-aquatic interface and are associated with high nutrient levels, high primary productivity and diversity of structural habitats which are utilized by a variety of organisms. Migratory birds and many fish species take advantage of coastal wetlands for feeding and nursery areas (Prince, et. al. 1992). They depend on the plant life along with diversity of invertebrates for habitat and sources of food. Furthermore, fish that are typically considered pelagic species of the Great Lakes will at some point in their life cycle take advantage of wetlands (Brazner 1997).

Humans are responsible for contributing to the degradation of the Great Lakes coastal wetlands. Activities such as dredging, draining, land filling, road building, shoreline development, and nutrient, sediment and contaminant loading (Brazner 1997) are greatly affecting coastal wetlands and the associated plant and wildlife. Many native plant species are adapted to seasonal and inter-annual fluctuations from the Great lakes. Human alterations which either artificially raise or lower water levels or prevent seasonal effects create a setting for invasive plants to establish (Tulbre et al. 2007). Combined with increased levels in nutrients, invasive species may push out the native plants along with the fauna dependent on them.

As greater understanding of the multitude of functions that wetlands serve, a way to assess degradation of wetlands has become a priority. Many types of biological indicators have been proposed. They have the potential to track change of wetlands through time, rank habitats, and diagnose cause of change (Dale & Beyeler 2001). In order for an indicator to be effective it should be representative of the structure, function, and composition of the ecological system for which it is being used (Dale & Beyeler 2001).

Seilheimer and P. Chow-Fraser(2006&2007) have proposed the Wetland Fish Index (WFI) as a way to assess Great Lakes coastal wetlands. Fishes are a good indicator of wetland integrity due to the varying degrees in which species are tolerant or intolerant to degraded water quality conditions. The relationship between fish distribution and associated water quality conditions have been well documented (Seilheimer and P. Chow-Fraser 2006 & 2007, Jude and Pappas 1992, Jacobus and Ivan, Uzarski et al 2005 and Brazner 1997). Correlation of species tolerance and wetland water quality forms the basis of the WFI. Therefore using fish as indicators can provide a simple method that is less costly and less time consuming than analyzing water chemistry for different levels of nutrients.

Our study aims to obtain a better understanding of the biological integrity of the Kalman-Harbor Cove Preserve. It is located in Emmet County, Michigan near the city of Harbor Springs on the Northern side of the Little Traverse Bay. The Little Traverse Conservancy acquired this 71-acre parcel of land in 2001 as part of a land trust that aims to preserve undeveloped habitat for native species (Bakersville et al 2006). The only known study previously conducted on the preserve used the Floristic Quality Assessment (FQA) which rated the preserve as a facultative wetland and a hotspot for biodiversity of plant species.

We hope to provide additional information about the current state of the preserve by surveying diversity of habitat, plant life, macroinvertebrates and fishes at the Kalman Preserve. We will apply the WFI to assess degradation of the wetlands and compare our results to that of the FQA as well as look at Shannon-Weiner Diversity values.

## Methods

We chose two specific sites on the Kalman preserve to sample for fish abundance, chemical analysis, macroinvertebrate richness, and estimates of vegetation present. The first was a small pond which was currently cut off from the bay. The second was in the bay along the shoreline. Between the bay and the pond existed a pebbly/sandy area with vegetation and generally saturated soils. It’s probable that at times the pond is directly connected and flows out into the bay and may currently be connected through underground sub-surface flow. Data were collected between July 21, 2008 and July 28, 2008.

We measured fish abundance using minnow traps baited with dog food (five kibbles per trap). In the pond, we placed one row of five minnow traps spaced three meters apart. The depth at each trap ranged from 47cm-60cm. In the bay two rows of five traps were used. Traps in the bay were spaced three meters apart in one row and five meters apart in the other. Trap depths ranged from 21cm-60cm, but on average were placed at depths of 42.5cm. Trap lines were deployed perpendicular to the shore. We collected fish and reset traps every two days except on one occasion we reset it after only one day. We had a total of four days of fish collection. Fish that could be identified on site were recorded and released and unknown species were brought back to the lab to be identified.

We used a 1x1 meter quadrat in order to assess the vegetation in both the pond and the bay. At each trap, we took a quadrat sample and noted percent floating, submerged and emergent vegetation. We also noted type of substrate as well as percent of uncovered substrate at each quadrat. All plants were identified in the field down to genera and some were identified to species.

Macroinvertebrates were sampled qualitatively using kick nets. Samples were taken in mucky, vegetated and sandy areas of the pond. In the bay we sampled along the cobble to rocky substrate. All macroinvertebrates were stored in ethanol and taken back to the lab to be identified.

Air and water temperature, dissolved oxygen, conductivity and pH were measured on site at both the bay and pond using a mercury thermometer, the Hach HQ 30d flexi, YSI 30 conductivity meter and the Accumet portable AP61 pH meter respectively. Water samples were collected at mid-depth using acid washed bottles and placed into a dark cooler for further lab analysis. Chemical analysis consisted of dissolved organic carbon (DOC), Chloride ($Cl^-$), Chlorophyll a (Chl), total phosphorous (TP), total nitrogen (TN), soluble phosphorous (PO4-P) and alkalinity (alk).

We calculated the average fish abundance, species richness, average catch per net per day and Shannon-Weiner diversity values. In order to adjust for differing numbers of traps used in the pond versus the bay, the average total abundance in the bay was calculated and compared to the total abundance in the pond. Any further mention of abundance will refer to the adjusted average abundance in the bay and the total abundance in the pond. Shannon-Weiner diversity values were calculated for the pond, the bay and combination of both using average catch per net per day. We first calculated diversity values separately for the east bay and for the west bay and then took the overall bay average.

We applied two methods to calculate the Wetlands Fish Index value using the following formula derived by Seilheimer and Chow-Fraser (2006):

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

where $Y_i$ is the presence or log10 abundance (log[x+1] of species i, $T_i$ is the value from one to three(indicating niche breadth), and $U_i$ is the value from one to five (indicating tolerance to degradation). We calculated an index value based on presence-absence data as well as a separate value based on abundance. To adjust for exotic species present we subtracted the square root of the proportion of exotic individuals present within the preserve.

**Results**

Average catch per net per day and fish species richness were higher in the bay than in the pond (Figure 1). In the bay, four species were represented with an average abundance of 2.56 fish per net per day. Longnose dace (*Rhinchthys cataractae*) comprised the majority (89%) of our catch in the bay. Other fish caught in the bay included rock bass (*Ambloplites rupestris*), round goby (*Neogobius melanostomus*), and spottail shiner (*Notropis hudsonius*). Abundance in the pond was only .45 fish per net per day and included members from three different species. Mudminnows (*Umbra limi*) composed 82% of the pond abundance. Other fish caught in the pond included banded killifish (*Fundulus diaphanus*) and blue gill (*Lepomis macrochirus*).

Substrate, vegetation type and percent cover varied within the Kalman preserve. The substrate in the pond consisted of mostly sandy muck but in some areas it was just sand. The majority of the pond contained no gap cover except for an area with small shrubs along the north edge providing minimal shade (maximum of 30cm from edge). Quadrat sampling near minnow traps showed the pond to have more cover and variety of vegetation than in the bay (Table 1).

*Brasenia schreberi* was the dominant floating vegetation and averaged 55% cover. *Chara spp*.was the dominant submergent species with 83% average cover of the substrate. The substrate in the bay consisted of a rocky bottom with hardly any vegetation except for along the shore. One out of ten minnow traps were located in vegetation which was comprised of *Schoenoplectus americana*, *35%* cover, and *Typha x glauca*,15% cover.

Macroinvertebrate richness was greater in the pond than in the bay (Figure 3). We found ten different taxonomic groups of macroinvertebrates in the pond, six of which were exclusive to the pond. Four groups were found in both the pond and the bay while only two groups were exclusive to the bay.

Temperature and nutrient levels tended to be higher in the pond (Table 2). The pond had a conductivity of 620.00µS/cm while in the bay it was only 283.45µS/cm. Total nitrogen and total phosphorous were also higher in the pond. We did find that there was higher dissolved oxygen and chlorophyll a in the bay as well as a higher pH.

Shannon-Weiner fish diversity values did not vary much between the pond and the bay. The average diversity value in the pond was .345 and .354 in the bay (Figure 4). Species abundance from the bay and pond were used to collectively calculate a Shannon-Weiner diversity value of .720. The WFI calculated for the entire wetland using total abundance was 3.73 and with the exotic species correction was 3.59. The score based upon presence-absence data was 3.63 and with the exotic species correction was 3.49. These values fell between a possible range of 1-5, where 1 is most degraded and 5 is least degraded.

**Discussion**

The pond was characterized by higher temperatures, greater levels of nutrients, greater plant species richness, and lower dissolved oxygen compared to the bay. The pond is located at the land-water interface and therefore any nutrient or sediment runoff from upland will be deposited into the pond. Nutrient deposition may then undergo retention, storage, and exchange. Aquatic plants and microbiota in the wetland are able to take advantage of high nutrients and low oxygen and contribute to the high primary productivity typically associated with wetlands (Wetzel 1992). The ability of the pond to act as a buffer, prevents high levels of nutrient runoff from directly flowing into the bay.

The pond contained both mudminnows (*Umbra limi*) and banded killifish (*Fundulus diaphanous*) which are both species considered to be intolerant of degradation (Seilheimer and Chow-Fraser 2007). Mudminnows thrive in shallow warm waters with low oxygen levels and also depend on areas with vegetation and mucky substrates for feeding and reproducing. They mainly feed on invertebrates and other small fish (Chilton et al 1984).

The bay was colder, had lower nutrient levels, higher pH, and higher dissolved oxygen. These conditions provided a much different habitat than that of the pond. We found species such as the longnose dace (Rhinichthys catarctae) and rockbass (Ambloplites rupestris) that prefer cooler, faster moving waters. Between the pond and the bay, the Kalman preserve wetlands provide a great variety of diverse habitats that can be utilized by many species of fish and macroinvertebrates.

We found a total of 12 different groups of macroinvertebrates between the pond and the bay which were potential sources of food for fish and other animals. We found the most variety in the pond. This is most likely related to greater diversity of habitats and high primary production. While we are not able to say anything specific about the tolerance level of different groups present in the pond and bay, the presence-absence data may be useful to compare increases or decreases in taxa richness over time. Macroinvertebrates are sensitive to chemical and physical changes and we will often see alterations in composition and abundance of different groups with increased nutrient levels (Smith et al 2007)

When water levels are high, the pond may be temporarily connected to the bay. This would cause the release of nutrients as well as exchange of fish from pond to bay and vice versa. One species of fish in the pond that would take advantage of such an event would be the bluegill (*Lepomis macrochirus*). The bluegill is known to shift from the littoral vegetation zone to the pelagic zone several times throughout its life history (Werner and Hall 1988). Other fish in the pond that become introduced to the lake could be food for piscivorous fish feeding along the shoreline.

Six out of the seven different fish species caught between the pond and bay were used to calculate the Kalman preserve WFI score. This score suggests a wetland that is only moderately degraded. Our results for the WFI agree with the past floristic assessment in that we have a site that is not highly degraded by human disturbance. We were not able to include longnose dace (*Rhinichthys cataractae*) in our calculation of the WFI because it was only encountered by Seilheimer and Chow-Fraser (2006 and 2007) at one wetland and was therefore not assigned niche breadth and tolerance values. According to the US EPA (2007) the longnose dace is considered a pollution intolerant species. Therefore it's possible that the inclusion of the longnose dace into our calculation of WFI will not have that great of an effect. However, tolerance values developed for use in the WFI are more robust as they take into account niche breadth and additional types of degradation besides pollution.

The WFI is able to tell us more about the biological integrity of our site than the Shannon-Weiner diversity index. Higher diversity doesn't necessarily reflect an undisturbed area. It's possible that in a disturbed site we may have high diversity with several invasive or highly tolerant species represented. Because the WFI is directly correlated with the Water Quality Index (WQI: Chow-Fraser 2006) we are able to understand more about the biological integrity of our site based upon which species of fish are present. There is well documented evidence that degradation of water quality can have great impacts on fish species compositions. For example, high nutrient and sediment loading can lead to high algal production, increased water turbidity, and a decrease in macrophyte abundance and diversity (Seilheimer and Chow-Fraser 2006). A decrease in macrophyte abundance may reduce food and protection from predators for the fish that are using the wetlands for reproduction and feeding.

The WFI provides a quantifiable measure with which we can be used to cross compare wetlands, as well as observe changes throughout time. This tool will be useful in assisting management decisions based on its ability to reflect more long term effects. It is able to do this because species assemblages will reflect the cumulative impacts of human disturbance as opposed to viewing short term fluxes in the wetland (Seilheimer et al 2009). It will be easier to make associations between human activity and disturbance to wetlands. Also it has been suggested that more pristine wetlands may be cheaper to preserve than waiting to rehabilitate a disturbed wetland. The WFI can therefore be used to point out wetlands that should be protected. It can also be used on wetlands that are on the verge of becoming degraded.


Figure 1: The red box indicates the location of the Traverse Bay on Lake Michigan. The Kalman Preserve is located on the north side of the bay near Harbor Springs in Emmet County, MI. The zoomed in photo in the top left shows the boundry of the preserve as well as where samples were taken in the

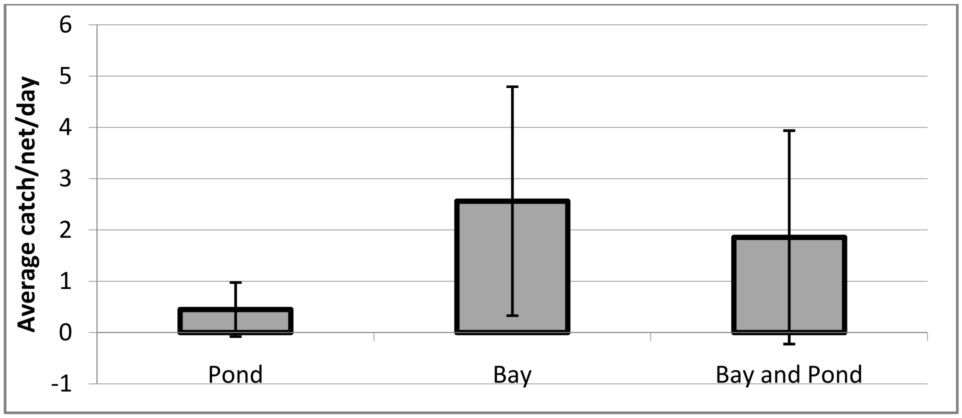


Figure 2: the average catch per net per day with two standard errors are shown for the pond, the bay, and the combined pond and bay at the Kalman Preserve in Emmet county, MI.

Table 1: Percent cover for emergent, floating, and submergent are shown for the pond and the bay at the Kalman Preserve. One quadrant(1x1m) was taken in the bay while the pond is based on an average of five quadrants.

| Vegetation Type | Species | Pond | Bay |
|---|---|---|---|
| **Emergent** | *Schoenoplectus validus* | 2.3 | -- |
| | *Schoenoplectus americanas* | -- | 35 |
| | *Typha x glauca* | -- | 15 |
| **Floating** | *Brasenia schreberi* | 55 | -- |
| **Submergent** | *Potamageton spp.* | 1 | -- |
| | *Utricularia spp.* | 18 | -- |
| | *Chara spp* | 83 | -- |
| | *Exposed Sediment* | 14 | 50 |

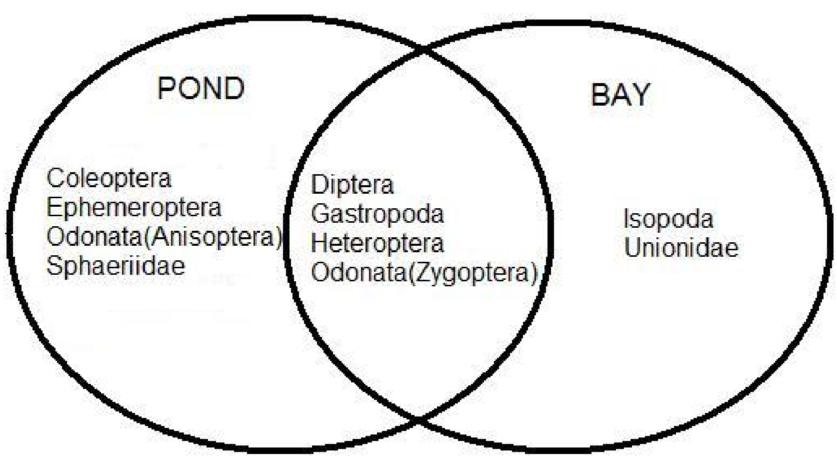


Figure 3: Presence of macroinvertebrates are shown for the pond and the bay at the Kalman Preserve. Groups shown in the middle were found in both locations

Table 2: Abiotic results are shown for the pond and the bay in the Kalman Preserve. Most samples were taken only once. Those that were taken more than once are noted where "n" equals the number of samples taken.

| | Pond | Bay |
|---|---|---|
| Water temperature(avg) | 24.5°C (n=5) | 22.9°C (n=5) |
| pH (avg) | 7.63 (n=1) | 8.63 (n=2) |
| conductivity (avg) | 620.00µS/cm (n=1) | 283.45µS/cm (n=2) |
| Dissolved oxygen | 9.19 mg/L | 10.76 mg/L |
| | 113.90% | 131.30% |
| Dissolved Organic Carbon | 21.47 mgC·L$^{-1}$ | 3.03 mgC·L$^{-1}$ |
| $Cl^-$ | 20.02mg/L | 11.30mg/L |
| Chlorophyll a | 1.8 µg·L$^{-1}$ | 4.9 µg·L$^{-1}$ |
| Total P | 13.0 µgP·L$^{-1}$ | 6.9 µgP·L$^{-1}$ |
| Total N | 1.266 mgN·L$^{-1}$ | .826 mgN·L$^{-1}$ |
| Soluble Phosphorus | 1.7 µgP·L$^{-1}$ | 0.5 µgP·L$^{-1}$ |
| Alkalinity | 337.4 mg$CaCO_3$·L$^{-1}$ | 189.8 mg$CaCO_3$·L$^{-1}$ |

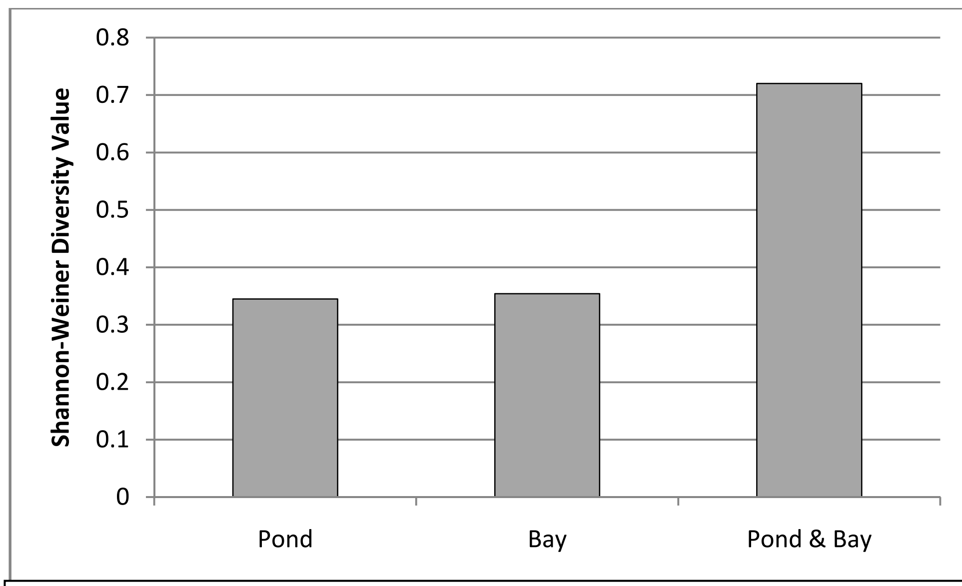


Figure 4: Average Shannon-Weiner Diversity Values were calculated separately for the pond and the bay at the Kalman Preserve. Species were then combined and applied to the Shannon-Weiner Diversity Index to calculate overall average diversity of the pond and bay combined.

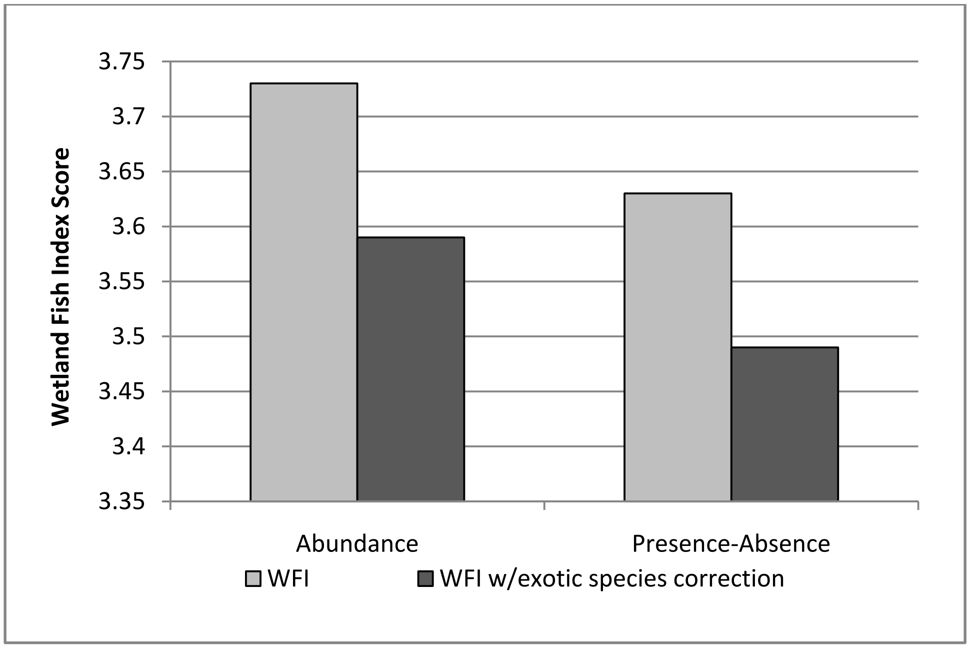


Figure 5: Wetland Fish Index Scores (Seilheimer and Chow-Fraser 2006&2007) were calculated using two different methods and then adjusted for the exotic species correction. One method used the total abundance values and the other used presence-absence data.

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WQI -3 most impacted conditions and +3 indicative of the most undisturbed sites

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