Chapter 5
Fish Community Indicators

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Introduction

Great Lakes coastal wetlands provide critical habitat for more than 80 species of fish (Jude and Pappas 1992). More than 50 of these species are dependent upon wetlands while another 30+ migrate into and out of them during different periods in their life history (Jude and Pappas 1992, Wilcox 1995, Wei et al. 2004). An additional 30+ species of fish may be occasional visitors to coastal wetlands based on occurrence in adjacent habitats (Jude and Pappas 1992, Wei et al. 2004).

As transitional systems between land and water, coastal wetlands are among the first habitats impacted by disturbances from adjacent uplands and/or pollutants from upstream (Mayer et al. 2004). Activities and pollutants that degrade wetland habitat may also pose threats to other near-shore and deepwater habitats if allowed to continue unabated. Since many pollutants accumulate in coastal wetlands and land-use changes in adjacent areas tend to affect them first, coastal wetlands can provide ”early warning” of potential threats to the Great Lakes ecosystem. The governments of Canada and the United States recognized this potential and initiated a process to identify and/or develop indicators of "ecosystem health" for wetlands and other Great Lakes habitats at the State of the Lakes Ecosystem Conference (SOLEC) held in Buffalo, N. Y. in 1998. Progress was reviewed and potential indicators were identified by working group members at SOLEC 2000 in Hamilton, Ontario. Potential indicators listed by the wetlands indicators working group included indices of biotic integrity (IBIs) based on invertebrates, fish, and plants, even though no broadly accepted protocol was available at the time for any of these biotic groups.

Great Lakes coastal wetlands occupy a relatively small percentage of the Great Lakes shoreline (e.g., about 11 % of the shoreline of the U.S. side of Lake Huron (Prince and Flegel 1995). Conversion of wetlands over the last 100 years has reduced the area of Great Lakes coastal wetlands by more than 50%, with losses greater than 95% in some areas such as western Lake Erie (Krieger *et al.* 1992). Sustainable management of the remaining wetlands and efforts to restore the large number of wetlands that have been converted to other land uses are critical to the long-term viability of the Great Lakes ecosystem. An important tool needed for the management and restoration of coastal wetlands is a system of assessment that will allow managers to monitor the health of these and adjacent coastal systems on a routine basis so that trends in wetland condition can be established and used to identify threats to these ecosystems.

Fish have long been included as key indicators in assessments of biotic integrity in streams (e.g., Karr et al. 1986, Lyons and Wang 1996) and to a lesser degree in lakes (e.g., Fabrizio et al. 1995, Whittier 1998) and estuaries (e.g., Jordan et al.1991, Deegan et al. 1997). Fish have received little attention as indicators of wetland conditions, but recognition of their ecological significance in Great Lakes coastal wetlands (Jude and Pappas 1992) has recently generated considerable interest in using fish as indicators for these habitats (Wilcox et al. 2002, Timmermans and Craigie 2003, Environment Canada and Central Lake Ontario Conservation Authority 2004, Uzarski et al. 2005).

Minns *et al.* (1994) developed a fish-based IBI for shallow areas of Great Lakes Areas of Concern that includes metrics sensitive to impacts by exotic fishes, water quality changes, physical habitat alterations and changes in piscivore abundance related to fishing pressure and stocking. This system has not been extended outside of the limited and often highly impacted Areas of Concern. The work of Brazner (1997), Brazner and Beals (1997), and Minns *et al.* (1994) demonstrated relationships between fish populations and wetland and/or near-shore habitats that suggested that development of a fish-based IBI for coastal wetlands was possible. Recently, Randall and Minns (2002) used an IBI to assess habitat productivity of nearshore areas (including coastal wetlands) of lakes Erie and Ontario and compared results to those obtained using their Habitat Productivity Index. Thoma (1999) developed a fish-based IBI for near-shore waters of Lake Erie. More recently, Seilheimer and Chow Fraser (2006) proposed a fish-based IBI that reflected degradation of the water quality of Great Lakes coastal wetlands. Despite promising results, Wilcox *et al.* (2002) concluded that development of wetland IBIs for the upper Great Lakes using macrophytes, fish and microinvertebrates was impractical. Even though some of their metrics showed potential, they concluded that natural water level changes from those that existed during data collection were likely to alter communities enough to invalidate metrics in subsequent years.

This problem was overcome when developing an integrity index using invertebrate assemblages in fringing coastal wetlands in Lake Huron by developing a method based on sampling any or all of four emergent plant zones, depending on the number of zones inundated (Burton *et al.* 1999, Uzarski *et al.* 2004). The IBI scores for a particular year were calculated by summing scores from each zone that were inundated when sampling occurred. As water levels decreased and zones were no longer inundated, the IBI scores changed, but metrics for even a single inundated zone proved to be effective in describing the condition of fringing wetlands of lakes Huron and Michigan between 1997 and 2002 – a period during which water levels decreased by more than 1 meter (Uzarski *et al.*, 2004). Based on these results, we hypothesized that fish-based IBI metrics developed using samples from each inundated plant zone, rather than using combined samples to develop one set of metrics for the entire wetland, would provide the flexibility needed to make the IBI useful over a wide range of lake levels. This makes our approach different from other recent efforts, including the approach used by the REMAP project of U.S.EPA, where multiple samples collected across the entire wetland were combined to produce one integrated sample per wetland.

Materials and Methods

Various methods exist for sampling fish from coastal margins. The most commonly used techniques are various forms of trap nets (especially fyke nets), seines and electrofishing. Each method has its strengths and biases, which vary depending on time of day, season, duration and intensity of sampling, and habitat. Comparative studies of the effectiveness of these techniques at describing the fish community and condition of Great Lakes wetlands have been conducted by Thoma (1999), Chow Fraser et al. (2006) and Ruetz et al. (2007). Given that agencies may have longstanding traditions and databases compiled using a particular type of gear, it would be desirable to develop metrics for each sampling class. Chow Fraser et al. (2006) observed that, although electrofishing and fyke netting each caught 60%-75% of the species present in a wetland, particular species and dominant functional groups tended to be gear specific. Metric responses to stress could be developed but patterns of response to particular anthropogenic pressures were unique to gear type. Thoma (2002) argued that nocturnal electrofishing was most effective at summarizing biodiversity in Lake Erie coastal wetlands and drowned river mouths. However, Chow Fraser et al. (2006) developed an effective fish index from daytime electrofishing only. The most recent sampling efforts of several groups have emphasized fyke net methodology (Brazner and Beals 1997; Consortium – Uzarski et al. 2005; GLEI – Bhagat 2005; REMAP – Simons et al. 2006) but since both electrofishing and fyke netting have been used effectively to characterize fish assemblages from Great Lakes coastal wetlands, details associated with each approach have been included in this report. However, the IBI metrics reported here have only been calibrated with catches obtained with fyke nets and additional calibration would no doubt be needed if there is a desire to use electrofishing data to score the metrics and compute an IBI.

Fish Sampling (Fyke Netting)

Fish sampling should be conducted using a minimum of three replicate fyke nets with 4.8-mm mesh in each dominant vegetation zone for one net-night (Uzarski et al. 2005, Brady et al. 2007). Sampling should correspond to the maturity of the vegetation in each system. The need to be able to identify plant zones will determine the earliest date at which sampling can be conducted (typically no earlier than mid-June). Sampling should not be conducted after the end of August as seasonal movements of fish to winter locations may bias estimates of community composition. Only dominant plant zones that can be definitively assigned to a dominant plant species or morphotype (i.e. visually more than 75% composition by one species or morphotype) (*Sparganium, Schoenoplectus, Nuphar/Nymphaea, Pontederia/Sagittaria/Peltandra, Typha, Zizania,* or *Eleocharis*) should be sampled to partition variation due to structure or habitat type. It is rare to encounter vegetation zones without an obvious dominant. If a zone without an obvious dominant is encountered, it should be avoided. Uzarski et al.'s (2005) IBI relied primarily on bulrush-

(*Schoenoplectus*), water lily (*Nuphar/Nymphaea)* and cattail-(*Typha*) dominated zones, and these zones should be sampled if present. Scoenoplectus zones can be divided into outer and inner zones in areas where this zone is more than 50-100m wide, since the outer edge of this plant zone may only support low stem density while inland zones may be sheltered enough from wave action by higher stem density to support different fish species than the outer zone. In high lake level years, inundated wet meadow zones may also be added as a different habitat.

Two sizes of fyke nets can be used, 0.5-m x 1-m openings and 1-m x 1-m openings. Smaller nets should be set in water approximately 0.25-0.5 m deep; larger nets are set in water depths > 0.50 m. Leads should be 7.3 m long and wings should be 1.8 m long. The depth of water in each plant zone will dictate net size used since the only difference between large and small nets is height. The nets should be set so that the top of the cod end is far enough above the water surface to prevent turtles and other air breathing vertebrates from drowning. The location for each net should be determined randomly/ haphazardly within each vegetation zone and should be set with at least 20 m between nets if possible. Nets should be placed perpendicular to the vegetation zone of interest, with leads extending from the center of the mouth of the net into the vegetation. Therefore, fishes in the plant zone or moving along the edge of plant zone are likely to be caught. Wings should be set at 45º angles to the lead and connected to the outer opening on each side of the net. When a defined boundary or edge of the vegetation type of interest is not found or difficult to reach, the nets can be fished lead to lead rather than just individually.

Fish Sampling (Electrofishing)

Although electrofishing data has not been used extensively to generate IBI scores for coastal wetlands (however, see Environment Canada and Central Lake Ontario Conservation Authority, 2004 for one exception), the methods described here are intended to provide a representative sample of the fish assemblage present at a Great Lakes coastal wetland and allow relationships among the assemblage or particular fish species, in-wetland habitat and human disturbance to be established at a number of spatial scales. The data will be suitable for calculating indices of biotic integrity, their individual metrics, and function- or species-based indicators of condition, assuming proper calibration has been completed for the sampling region and wetland type. These methods have been tested and found to be feasible and effective across the Great Lakes basin (Brazner et al. 2007, Trebitz et al. *in press*) in all of the main Great Lakes coastal wetland types (e.g., fringing, protected, drowned river mouth; see Keough et al. 1999 and Albert et al. 2005 for details on types).

Selection of Great Lakes coastal wetland study sites for electrofishing will depend on specific study goals but will be limited to locations where boat access is feasible, since boat-mounted gear is required to effectively sample most Great Lakes coastal wetlands. Access is not a trivial problem for electrofishing coastal wetlands because boat launches have not been developed for many sites, and many wetlands along high-energy shorelines develop partial or complete barrier beaches across their mouths, preventing access from the open lake. In addition, the distance from existing launches is often prohibitive due to safety concerns associated with travel across the open Great Lakes in small, flat-bottomed boats.

It is recommended that all fish sampling be conducted within a two-month period during July and August. This corresponds with the peak growing season for aquatic vegetation and is the season of highest fish diversity and abundance in Great Lakes coastal wetlands (Brazner 1997, Brazner and Beals 1997). It is also a time of year when abiotic conditions (water temperature, lake level, stream discharge) are relatively stable and when fish occupying Great Lakes coastal wetlands are primarily resident species rather than spring or fall migrants. Karr et al. (1986) suggested that capture of primarily resident species was essential when data were intended to be used in metric calculations for indices of biotic integrity.

Assuming sites have been selected by an acceptable methodology and field access is deemed feasible, the first step once in the field is to select sampling transects. Since wetland habitat structure appears to be organized by fluvial zones (channel areas, back-bay areas, lacustrine areas - Trebitz et al. 2005) and habitat structure appears to structure Great Lakes coastal wetlands fish assemblages (Brazner and Beals 1997; Uzarski et al. 2005), transect selection and fish sampling are recommended at the fluvial zone scale. Measures can later be scaled up to the whole wetland scale if desired for comparisons with whole wetland habitat measures.

Samples within fluvial zones should be made along 100-m reaches of shoreline (Trebitz et al. in press). In general, transects can be treated as replicates to examine differences in fish assemblages within or among fluvial zones or other within-wetland factors such as vegetation type, or aggregated to the wetland scale by area-weighting or simple summation.

It is also recommended to use seven sampling transects based on field trials (Trebitz et al., in press). Shocking and processing the fish at seven transects typically requires about 4-5 hours in the field, an amount of time that typically allows the field crew to complete a number of other sampling activities at the same wetland within one day, or alternatively to sample fish at two different wetlands on the same day. The amount of sampling that can be completed in a day will depend on a number of factors, including difficulty of access to and movement within the wetland, size of the wetland, distance between sampling locations and number of fish captured. However, this method has been tested and utilized at more than 60 Great Lakes coastal wetlands and the 4-5 hour time to completion estimate was rarely exceeded.

Approximate transect locations can be identified before going out in the field using geographic analysis of digital orthophotoquads for each site. On the orthophotoquads, the perimeter of the standing water portion of the wetland is divided into seven equal length segments. Sampling locations can be initially set to correspond with segment boundaries on the orthophotoquad. In the field, the actual sampling locations should be adjusted as necessary so that each 100-m transect falls entirely within one fluvial zone, to accommodate altered water levels or wetland morphology, and to provide the best representation of the habitat types and fluvial zones that are present. This procedure (approximately equally spaced transects, with some adjustments in the field) ensures good spatial coverage of the wetland inundated area (i.e., crews not just sampling the closest or most accessible parts), while allowing field crews to deal with the various contingencies that may arise.

Once transects have been identified and adjusted for habitat representativeness, they should be clearly marked along the shoreline so they can be easily located by all field crews during any revisits to the sites. Recording GPS coordinates and other nearby landmarks are also recommended so that transects can be relocated even if shoreline markers have been removed or are not desired by landowners. Covariate data (dominant vegetation, depth, substrate characteristics, other forms of disturbance, basic water chemistry, turbidity) should be measured at each transect as time and resources permit. This information is often important in selecting the appropriate metric to apply to a particular wetland or reach (Table 5-1).

Electrofishing in Great Lakes coastal wetlands is most effectively accomplished from smaller, lighter-weight boats than are typically used in larger lake and river environments. Smaller boats provide more ready access to the very shallow waters that predominate in coastal wetland habitats (they can be pushed with an on-board pole in shallow and densely vegetated areas where using the motor is impractical) and are easier to launch at the less-developed boat landings typical of these sites. A 5-m long, flat-bottomed boat with a shallow v-shaped bow will optimize flat working space within the boat while minimizing draft and providing some protection from waves if travel across the open Great Lakes is required to access a site. Additionally, a removable front railing on the boat is useful for getting under low bridges that would otherwise limit access to substantial portions of some wetlands. It is recommended that the boat be equipped with a 1.0-m Wisconsin ring anode fitted with stainless steel droppers mounted on a 3.0-m boom, but boom length will need to be adjusted to boat size so that the Wisconsin ring is centered approximately 1.5m in front of the bow. A ring-shaped anode is recommended because it is less likely to become entangled in emergent vegetation than other electrode configurations.

A 3-m stainless steel cable suspended from the boat rail is recommended as a cathode. This has been found to be a more effective cathode design for coastal wetland sampling than the more typical use of the boat-bottom surface; but using the boat bottom surface or a metal plate mounted on nonmetallic hulls would be an acceptable approach as well. Current should be generated with at least a 5.000`watt generator and voltage adjusted to produce current (in-water amperage) at a level that will be effective in stunning fish while minimizing potential harmful effects. This level varies among lakes and between locations within a lake depending on conductivity, depth, substrates and other factors, but is often in the 5 to 6 amp range. This level is considerably higher than what we have found to be effective in most stream habitats (≈ 2 amps), but is necessary to be effective in many Great Lakes coastal wetland habitats, particularly those with highly organic or sandy substrates. Minimizing potential harmful effects should always be paramount, so assessment of minimum effective current will need to be completed at each site immediately before sampling begins. An output setting of 60-120 pulses per second of direct current is recommended to achieve these results. Output setting and effective current delivered to the water should be maintained consistently across all sites.

Each transect should be fished an equal time across all wetlands. A total of 10-15 minutes of continuous shocking is recommended per transect parallel to shore. Although it is not necessary and meaningful data can be obtained without it, it is recommended that one weights the time spent fishing in different vegetation zones (e.g., emergent, submergent and open water, other) at each transect by the predominance of each of these habitats at a particular transect. Estimating the areal coverage of the different vegetation zones can be done quickly by visual estimation adjacent to the transect immediately before beginning fishing. Habitat crews can provide a more precise estimate of this coverage after fishing has been completed if deemed necessary. The weighting of vegetation zones is particularly important if certain metrics or indicators are based on fishes associated with particular plant zones (e.g., Uzarski et al. 2005). For example, if 10 minutes has been selected as the total time for each transect, and 25% of the aquatic portion of the site is estimated to be occupied by emergent plants, 50% by submergent plants and 25% of the site is open water habitat (macrophytes not present or rare), five minutes should be allotted to sampling in the submergent zone and 2.5 minutes in both the emergent and open water zones. All effort should be spread evenly across the 100 m transect in each designated zone. If weighting time fished by vegetation zones is not incorporated into the design, then all areas within the transect should be fished as exhaustively as possible within the time frame allotted.

Fish from each of the vegetation zones should be placed in separate coolers as they are captured and worked up separately if data stratification by vegetation zone is desired. Data can be aggregated later if analyses are being conducted at the scale of transects within wetlands or at the scale of entire wetlands. Since it is likely that fish data will be analyzed relative to other biotic or abiotic data, some thought should be given to matching the scales at which abiotic data are sampled to the scale of fish sampling. For example, vegetation cover and composition are readily surveyed at spatial scales matching the fish transects (Trebitz et al. 2005), and water quality data can be collected from the midpoint of each transect.

At each transect, vegetation zones should be fished to the middle of the wetland at each transect not to exceed a maximum distance of 100 m from shore. The 100-m limit is recommended because greater distances create a sampling transect that is impractical for most field crews to effectively sample, particularly if all seven locations to be sampled in a wetland are configured in a similar manner. When large open water areas are present, the width of open water zone fished should be limited to the greater of the two widths from the emergent and submergent zones. For example, if the emergent zone was 20 m wide and the submergent zone was 40 m wide, only 40 m of the open water zone would be fished even if there was a much larger area of open water present. Similarly, if there was 10 m of emergent zone and 20 m of submergent zone only 20 m of open water would be fished. In channel or backwater areas that are less than 25 m wide, emergent and submergent zones on both sides of the channel/backwater should be fished if necessary to meet the calculated fishing times for each area.

Fish Enumeration and Identification

Regardless of the capture method, fishes greater than 25 mm should be identified to species and enumerated so that diversity indices can be calculated. Catch per net per night or per minute of electrofishing should be recorded for each species caught. Ten to 20 specimens of each species and approximate life stage based on regional size-at-age relationships (YOY, yearling, adult), should be chosen randomly for measurement (total length, evidence of deformities, ectoparasites, lesions or tumors, etc.); these data are not needed here but should be obtained for future use. Depending on study objectives, all fish or a representative subsample may need to be weighed and measured for total length before release. If a fish cannot be identified in the field, specimens should be collected for later identification in the lab. Whenever possible, auxiliary (covariate) physicochemical data (water chemistry, depth, temperature, etc.) should be recorded before and/or after sampling. This information can later be used to explain variability or anomalies in catch data. Recommended covariate measurements are summarized in Table 5-1.

Worksheet for Calculating IBI Scores

IBI use and interpretation of results

The recommended fish-based index of biotic integrity metrics for Great Lakes coastal wetlands are those of Uzarski et al. (2005). It is important to recognize that the metrics reported here are based on fyke net catches only and will need to be adapted for other fish capture methods. Scoring for each metric is calculated from mean values per net-night (Figure 5-1) in *Schoenoplectus* and *Typha* zones when a mean of at least 10 fish are captured per net per vegetation zone. If fewer than 10 fish are captured or a sample is suspected to be atypical, an additional net-night is recommended. Additional sampling increases sample sizes without altering community composition (Brady et al. 2007).

***Schoenoplectus* Zone:**

1. Mean catch per net-night:
<10 score = 0 | 10-30 score = 3 | >30 score = 5

2. Total richness:
<5 score = 0 | 5 to <10 score = 3 | 10 to 14 score = 5 | >14 score = 7

3. Percent non-native richness:
>12% score = 0 | 7% to 12% score = 3 | <7% score = 5

4. Percent omnivore abundance:
>70% score = 0 | 50% to 70% score = 3 | <50% score = 5

5. Percent piscivore richness:
<15% score = 0 | 15% to 25% score = 3 | >25% score = 5

6. Percent insectivore abundance:
<20% score = 0 | 20%-30% score = 3 | >30% score = 5

7. Percent insectivorous Cyprinidae abundance:
<1% score = 0 | 1%-2% score = 3 | >2% score = 5

8. Percent carnivore (insectivore+piscivore+zooplanktivore) richness:
<60% score = 0 | 60%-70% score = 3 | >70% score = 5

9. White sucker (*Catostomus commersoni*) mean abundance per net-night:
0 score = 0 | >0 to 0.4 score = 3 | >0.4 score = 5

10. Black bullhead (*Ictalurus melas*) mean catch per net-night:
0 score = 0 | >0 to 3 score = 3 | >3 score = 5

11. Rock bass (*Ambloplites rupestris*) mean catch per net-night:
0 score = 0 | >0 to 4 score = 3 | >4 score = 5

12. Alewife (*Alosa psuedoharengus*) mean catch per net-night:
>11 score = 0 | 1 to 11 score = 3 | <1 score = 5

13. Smallmouth bass (*Micropterus dolomieu*) mean catch per net-night:
0 score = 0 | >0 to 5 score = 3 | >5 score = 5

14. Pugnose shiner (*Notropis anogenus*) mean catch per net-night:
0 score = 0 | >0 to 5 score = 3 | >5 score = 5

Figure 5-1. Mean values per net-night for Schoenoplectus zones. For further reference, see Appendix C (Uzarski, et al. 2003) at the end of this document.

Typha Zone:

1. Percent insectivore catch:
<40% Score = 0 40% to 80% score = 3 >80% score = 5

2. Insectivorous Cyprinidae richness:
0 to 1 Score = 0 >1to 3 score = 3 >3 score = 5

3. Percent Centrarchidae abundance:
0-30 score = 0 >30 to 60 score = 3 >60 to 80 score 5 >80 score = 7

4. Centrarchidae richness:
0 to 1 score = 0 >1 to 3 score = 3 >3 score = 5

5. Mean Shannon Diversity Index:
<0.2 score = 0 0.2 to 0.7 score = 3 >0.7 score = 5

6. Mean evenness:
<0.2 score = 0 0.2 to 0.6 score = 3 >0.6 score = 5

7. Longnose gar (*Lepisosteus osseus*) catch per net-night:
0 score = 0 >0 to 0.5 score = 3 >0.5 to 2 score = 5 >2 score = 7

8. Largemouth bass (*Micropterus salmoides*) abundance per net-night:
0 to 2 score = 0 >2 to 30 score = 3 >30 score = 5

9. Rock Bass (*Ambloplites rupestris*) catch per net-night:
0 to 1 score = 0 >1 to 5 score = 3 >5 score = 5

10. Bluegill (*Lepomis macrochirus*) abundance per net-night:
0 to 3 score = 0 >3 to 20 score = 3 >20 to 30 score = 5 >30 score = 7

11. Lepomis catch per net-night:
0 to 5 score = 0 >5 to 20 score = 3 >20 to 50 = 5 >50 score = 7

Figure 5-2. The IBI of Uzarski et al. 2005 recommend by the GLCWC. Data are collected using fyke nets. For further reference, see Appendix C (Uzarski, et al. 2003) at the end of this document.

Table 5-1. Recommended Landscape and Water Quality Parameters to Record During Field Surveys

Parameter	Instrument	Consortium	GLEI	FQI (WQI)
TP	Water sample	X		*X*
TN	Water sample	X		X
TSS	Filtered sample	X	X	X
Chl *a*	Filtered sample	X		X
SRP	Water sample			X
TNN	Water sample			X
TAN	Water sample			X
Temperature	Multimeter	X	X	X
Conductivity	Multimeter	X	X	X
PH	Multimeter		X	X
DO	Multimeter	X	X	X
Inorganic SS	Filtered sample			X
Tubidity	Turbidimeter/Secchi disk	X	X	X
Water depth	Meter stick		X	X
Net distance from shore	Range finder/tape measure		X	
Substrate texture	Visual estimate		X	
Organic content	Sediment Sample for LOI		X	
Substrate particle size	Sediment sample (composite)		X	
Emergent plants (species, % cover, distrib.)			X	
Floating plants (species, % cover, distrib.)			X	
Submerged plants (species, % cover, distrib.)			X	
Shoreline features (land use at closest shoreline)			X	
Wetland hydrogeomorphic type		X	X	X
Adjacent land use				X
Set time (start)			X	X
Strike time (end)			X	X
Wave & wind conditions			X	X
Air temperature				X
Ecoregion				X
Relative water level		X	X	X

Limitations and alternate analyses

The recommended IBI is specific to only two plant zones. However, data should be collected from any/all plant zones encountered. IBIs will be developed for additional plant zones as data permits. The plant species that dominate in a particular area are determined by the habitat and physico-chemical features of the wetland and adjacent landscape. *Schoenoplectus* zones are typical of coastal wetlands that have sandy substrates, clear water and relatively low levels of nutrients. *Typha* zones tend to have more organic sediments and higher nutrient content. Ordination of fish IBI scores for the two plant zones indicate that the IBIs are not universal indicators of generalized anthropogenic stress. The *Typha* IBI varies in response to pressures related to increasing population pressure and associated loss of forest cover and increased residential and commercial use of adjacent land. In contrast, the *Schoenoplectus* IBI is responsive to increasing intensity of agricultural land use and point source discharges (Bhagat et al. 2007). Therefore, sampling both vegetation classes is important for interpreting what types of land use activity may be most responsible for altered fish community health where both zones occur.

If sampling is conducted in areas or habitats that lack vegetation entirely or have different dominant vegetation – such as a mixture of floating leafed vegetation including water lilies – alternate fyke net-based metrics are theoretically available if the appropriate covariates have been collected at the time of sampling. The fish quality index (FQI; Seilheimer and Chow Fraser 2006) relates community composition to a nutrient-dominated water quality index (WQI). As mentioned above, the Consortium-developed indices of biotic integrity (Fish-IBI) are based on multiple metrics for Typha & Schoenoplectus-dominated wetlands in relation to water quality and agricultural/urban land-use stresses (Uzarski et al. 2005). The Great Lakes Environmental Indicator (GLEI) metrics are derived from multivariate analyses of fish species relative abundances ordinated against agricultural and urban development stress gradients (Bhagat 2005; Bhagat et al., in prep).

Bhagat (2005; in prep) used a multivariate approach of fish community assessment to develop indicators of coastal margin condition based on relative abundances of species captured in fyke nets. Cluster analysis was used to distinguish unique groupings of reference sites based on relative abundances of fish species. A discriminant function analysis model distinguished the clusters on the basis of ecoregion and seven other environmental variables. Bray-Curtis ordination was then used to assess changes in fish community across 143 sites sampled with respect to two classes of human activity: agriculture and population density. Population density related stress was observed to have stronger effects than agriculture-related stress. Her assessment included nonvegetated locations (high energy coastlines and embayments), as well as coastal wetlands. It was especially noteworthy that species considered to be indicators of degraded conditions in cold, nutrient-poor northern ecoregions were found to be indicators of reference conditions in warmer, more mesotrophic southern ecoregions. This emphasizes the importance of collecting habitat and physicochemical data at the time of sampling, as it provides important information on the reference community that should be expected in a particular wetland.

Each fyke net-based index still needs validation using data external to that employed in model creation. However, the GLEI-derived land-use based stressor scores offer a basinwide, common suite of stressor measures against which to assess each index because scores exist for the entire U.S. Great Lakes coast. Scores for Canada are partially complete.

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Appendix 5-1. GREAT LAKES COASTAL WETLANDS DATA SHEET - Electrofishing

Page___of _____

Date_____________ Wetland______________________ Type: Riverine Protected

Fluvial Zone: Channel Back Bay Lacustrine Mouth

Lake_______________ Transect#______ Lat_________________ Lon_________________ Gear: Boat Tote Barge

Voltage_________ Amps_________ # GPP Seconds Fished________ Total Time Fished (min)_______ Veg. Zone: Emergent Submergent Open Mixed

Distance Fished - Length (m)______ Width (m)_______

L=length(cm), W=weight(g), C=condition

Species/Age		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Comments
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	C																
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Anomalies: A=anchor worm, B=black spot, C=leeches, D=deformities, E=eroded fins, F=fungus, I=ich, L=lesions, N=blind, P=other parasites, Y=popeye, S=emaciated, W=swirled scales, T=tumor, Z=other (H-heavy =>20%, L-light=<20%)

Appendix 5-2.

Field Equipment Checklist
For fish and accompanying chemical/physical (covariates) sampling

<u>Pre-sampling checklist</u>:

______Conductivity meter

______ Turbidimeter

______DO meter/probe/repair kit

______1 L water sample bottles (at least 3/site)

______Tape

_____Mechanicalpencils

______Field notebooks

_____Meter stick

______6 Fyke nets

______Fish processing boards

______Permanent marker

______Metal conduit (42 pcs.)

______Cooler and ice (depending on temp)

______Waders or boots

______ Insect repellent

______Cell phone

______Filter apparatus

______Filters/forceps

______Metal hand pump/tubing bottles

______250 mL sample (at least 3 per site)

______Buckets

<u>In field</u>:

Water samples → surface 1 L (1 sample per station)

Fish samples (nets) → 3 per station