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Determining the Health of the Humber River Using Fish as Bioindicators

INTRODUCTION:

Over the past few years, initiatives such as the Great Lakes Water Quality Agreement have been made between the United States and Canada in an effort to protect our major source of freshwater (Shear *et al.* 2003). There has been much effort to define the concept of 'ecosystem health' in order to better monitor these aquatic communities and it involves the biodiversity and physical health of the populations that are part of the ecosystem as well as the environment that supports them (Shear *et al.* 2003). This report measures biodiversity in fish populations in the Humber River in order to estimate ecosystem health. It is expected that the health of the Humber is poor considering it is surrounded by an urban environment and connects to a Lake already suffering from problems such as increasing presence of invasive species.

METHODS:

The study was carried out in the Humber River at Étienne Brûlé Park, Toronto, Ontario, Canada (43º 39′ 10″ N, 79º 29′ 35″ W) (Fig. 1). Sampling took place for three hour periods in the morning (from 09:00-12:00) and the afternoon (14:00-17:00) on Tuesday October 3, and Tuesday October 10, 2006. The morning of October 3rd, was moderately warm (18ºC) and it raining such that the river was much higher and faster moving than during the other sampling times. The weather that afternoon was sunny and warm (22ºC). The weather on October 10 was partly cloudy and cooler: 12ºC in the morning and 14ºC in the afternoon. Three types of habitat were sampled. The riffle habitats were rocky, usually with no vegetation and ranged in depth from 0.10-0.57 cm and in current from 0.2-1.4 m/s. The substrate for the edge environments was mud and rock. These environments had more vegetation than the riffles and ranged in depth

from 0.11-0.53 m and in current from 0.0-1.8 m/s. The pool environments had a substrate of rock and mud, little vegetation, depth of 0.13-0.60 m and a current of 0.00-0.43 m/s.

Seine nets both 2 and 3 m long were used at the riffle and pool environments, and 0.3 m diameter dip nets were used at all three environments by collection groups of 3-4 students. Except when conditions prevented it, the nets were moved upriver and the distance they were moved and in some cases the amount of time in the water was recorded (Appendices A & B). Minnow traps were also set in each environment in the morning of both days and collected at the end of the afternoon sampling session as a method of passive sampling. The data were then normalized by dividing the number of fish caught each attempt by the product of the diameter of the net and distance it traveled. This result was then averaged over collection groups, session (morning and afternoon) and finally over both days to yield a final result. Minnow trap data and active net data were kept separate because they reflect the different sampling strategies.

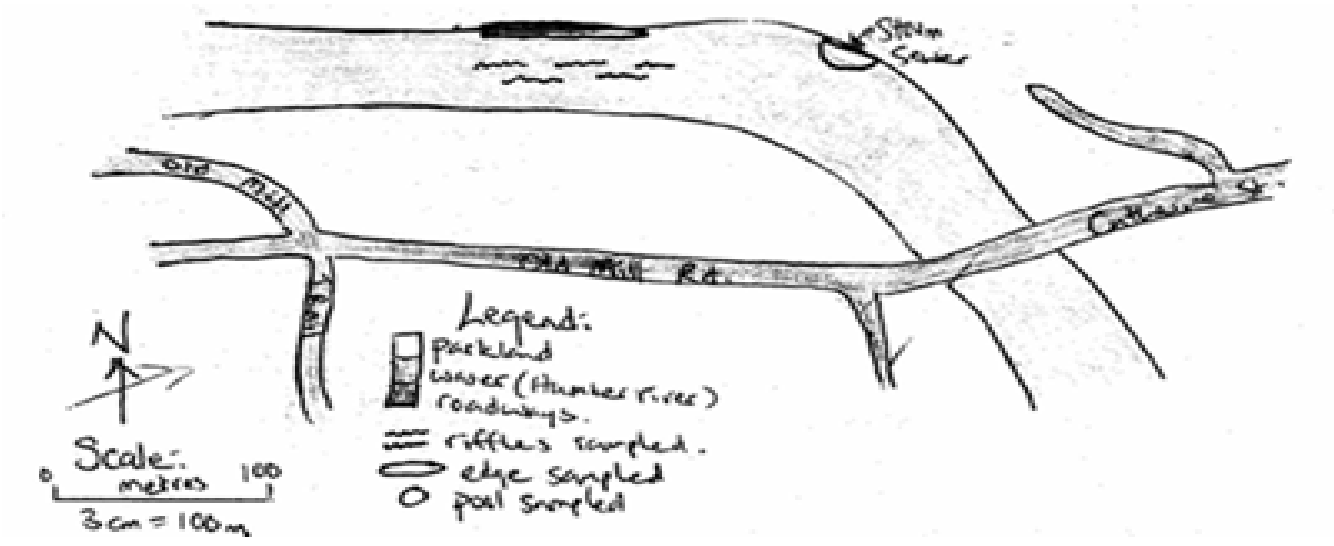

Figure 1
Map showing Étienne Brûlé Park and region of the Humber River sampled.

RESULTS:

Table 1
Mean abundance (number/m^2) of fish species sampled in three habitats of the Humber River (at Étienne Brûlé Park, Toronto) on October 3 and October 10, 2006 using seine and dip nets.

Species	Pool	Edge	Riffle	Total
River chub	0.009	0.052	0.000	**0.061**
Creek chub	0.589	0.347	0.221	**1.158**
Hornyhead chub	0.000	0.000	0.000	**0.000**
Common shiner	33.011	3.245	1.436	**37.693**
Emerald shiner	0.000	0.023	0.001	**0.024**
Johnny darter	0.027	0.161	0.005	**0.193**
Rainbow darter	0.000	0.250	0.009	**0.259**
Longnose dace	0.013	0.304	0.402	**0.720**
Blacknose dace	0.005	0.000	0.005	**0.010**
Fathead minnow	0.000	0.000	0.000	**0.000**
Bluntnose minnow	0.208	0.000	0.004	**0.212**
Common Carp	0.000	0.000	0.000	**0.000**
Largemouth Bass	0.000	0.000	0.000	**0.000**
Rock bass	0.000	0.046	0.014	**0.060**
Pumpkinseed	0.018	0.029	0.000	**0.047**
Brook stickleback	0.000	0.000	0.000	**0.000**
Bullhead catfish	0.000	0.000	0.002	**0.002**
Stonecat catfish	0.000	0.000	0.000	**0.000**
Northern Hog Sucker	0.000	0.000	0.000	**0.000**
White Sucker	0.000	0.000	0.000	**0.000**
Log Perch	0.000	0.000	0.006	**0.006**
Other sp. (round goby)	0.020	0.056	0.024	**0.100**
Total	**33.900**	**4.513**	**2.130**	

Active sampling (seine and dip nets) resulted in the identification of 13 species of fish in total (Table 1). Five species were present in all three habitats: creek chub, common shiner, Johnny darter, longnose dace and round goby. Two species were present in only one habitat: both the bullhead catfish and log perch were present only in riffle habitats. The remaining species were found in a combination of two out of three of the environments. In contrast, the passive minnow traps caught fish in only pond and edge environments, and common shiners were most plentiful (Appendix C). Of the five most common fish overall, the top three were found in all habitats: the common shiner, creek chub and longnose dace. The fourth and fifth

most common fishes were found mostly in one habitat: the edge for the rainbow darter and pool for the bluntnose minnow. Lastly, general tolerance to organic pollution, sediment and warm water was tallied for each species identified as described by Scott and Crossman (1973). The data show 67% of the species were tolerant, 25% were moderately tolerant and only 1 species, the rainbow dance to be intolerant to these conditions (Appendix D).

DISCUSSION:

The prevalence of common shiner in each environment and both the active and passive samples is not helpful for determining the health of the Humber River as it is a species generally tolerant to organic pollution, sediments and warm water. Similar conclusions can be drawn for the other two most common species: creek chub and longnose dace as well as the Johnny darter as they are also tolerant species present in all environments. The fifth most common fish, bluntnose minnow, is also a tolerant species; however it was found mostly in pool environments, which happened to be near a storm drain (Fig. 1). This fish was only caught during the morning of October 3rd (Appendix A) so it is likely that increased sediments and turbulence caused by the rainfall improved our chance of sampling this fish, not a major degradation of the Humber River. The fourth most common fish, the rainbow darter (0.259 fish/m^2) is a species rated generally intolerant. Although this was the only species sampled that was rated intolerant, its relatively high density suggests that the Humber River does not suffer excessively from these problems. The two species that were found only in one habitat were found at very low densities: 0.002 fish/m^2 and 0.006 fish/m^2 for the bullhead catfish and log perch respectively. The log perch is a moderately tolerant species which also suggests that the Humber River is relatively healthy, while the bullhead catfish is yet another tolerant species. Although individually, tolerant species do not help determine the environmental degradation of the river, the high number of tolerant

species may suggest that there is a presence of some combination of organic pollutants, sediments and warm water. In addition to this, Shear *et al*. (2003) claim "mature and relatively stable communities tend to contain proportionately more organisms that are longer lived and have specialized and demanding habitat requirements." The Humber River displays proportionately more fish that are generalists and tolerant suggesting the fish communities may not be stable, one measure of ecosystem health.

Similar sampling projects were undertaken by the ENV234 classes of 2004 and 2005, and analysis of this data shows that the total number of species has decreased over three years from 16 to 15 and then to this year's 13. From 2004 to 2006, the percentage of tolerant species rose steadily from 63% to 67% and the percentage of moderately tolerant species dropped from 31% to 25%. These changes as well as the large numbers of tolerant individuals in the Humber River seem to suggest again that the ecosystem's health is not ideal.

The most obvious evidence of degradation of the Humber River is the presence of the invasive species, the round goby. It was present in all three habitats and was found to be the seventh most common fish at 0.100 fish/m^2. In addition to this, the round goby was not present in the 2004 sample, and increased from a presence of 0.032 fish/m^2 to 0.100 fish/m^2 from 2005 to 2006. This is worrisome as it may indicate that this invasive species is becoming better established in the Humber River ecosystem which has the potential to cause problems for its native inhabitants in the future. It is interesting to note that in this case, presence/absence data is most helpful in drawing conclusions as it highlights trends that were obscured by the small sample sizes and consequent variability. Since presence/absence data (especially in the case of the round goby) supports the conclusion that the Humber is becoming unhealthy, it would have been sufficient for this ecological survey.

Staying with the classification system outlined in Shear *et al.* (2003), these interpretations of the data support the conclusion that the Humber River ecosystem is mixed/deteriorating. However, because the sample size was very small, the presence of the round goby in recent data but not in 2004 may simply be due to chance. In addition to this, the overwhelming presence of pollution and sediment tolerant fish may not actually indicate that the environment has a problem with either factor: the fish may be well-suited to water temperature, depth or other factors that were not considered in the analysis. This could be a reasonable interpretation and further sampling and analysis would be required, but since the conclusion of lower ecosystem health is supported by the presence of the round goby and conclusions made by Shear *et al*. (2003) and the area has been identified as a Toronto and Area Region of Concern by Environment Canada (http://www.on.ec.gc.ca/water/raps/toronto/intro_e.html), some environmental degradation is likely the case.

It has already been mentioned that the small sample sizes of this study increase variability in the results and therefore lower precision. In addition to this, there were a number of different sources of error for this study such as the presence of fishermen, which had the potential of reducing the number of fish in the area by disturbing their habitats, and as well on October 3rd, increased contamination of the water due to the rainfall which had the potential of increasing the number of sediment and pollution-tolerant fish. As discussed above, the effect of increased contamination was likely observed and recorded through the increased proportion of bluntnose minnow that morning. Unfortunately, with such small sample sizes, it is unlikely the effects of these errors were minimized when combining all the data – a larger survey is needed to accomplish this.

Fish are just one bioindicator used for aquatic ecosystems. As indicated in Shear *et al*., (2003) 80 indicators were chosen to monitor the Great Lakes basin including bioindicators such as contaminants in snapping turtle eggs and nesting water birds, as well as diversity and abundance of birds and amphibians. In the case of the Humber River, no amphibians were observed during the sampling, and very few species of bird were present. Therefore, fish are likely the best choice as indicators of ecosystem health they are easily caught and present in large numbers as well as a variety of different species, so small fluctuations in health can theoretically be observed.

The conclusion that the Humber River has mixed/deteriorating health is supported by preliminary data for the State of the Lakes Ecosystem Conferences review of the Great Lakes basin. Of 26 rated indicators, 10 are rated mixed while 7 are rated mixed/deteriorating and the introduction of exotic species (such as the round goby) is rated poor (Shear *et al*. 2003). In addition to this, zebra mussels used as biomonitors for Lake Ontario and Lake Erie by Comba *et al*. (1996) were found to contain both PCBs and the insecticide mirex also suggesting that the Great Lakes basin including the Humber River is contaminated with anthropogenic chemicals. In order to better determine the health of the Humber River ecosystem, this study should be continued. The number of samples needs to be greatly increased both spatially (taken at many points along the river) and temporally (taken throughout the year) in order to get a better inventory of the fish that live there. Another possible direction that could be taken is more holistic: if the goal is to truly understand the state of the Humber River, the entire Humber watershed needs to be studied and understood. Such a survey would include terrestrial plants and animals, amphibians, birds and aquatic bioindicators such as fish. Aquatic ecosystems such as the Humber River are complex and have the potential to be fragile. Through the monitoring

and action by groups such as the Humber Watershed Alliance (http://www.trca.on.ca/water_protection/strategies/humber/) and continued study we will be better able to monitor the degradation of the Humber River and determine actions required to prevent human impacts such as the introduction of the round goby in the future.

Literature Cited:

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Appendix A

COLLECTION RECORD, HUMBER RIVER
One member of your group will be responsible for transferring data to the TA (details to follow)

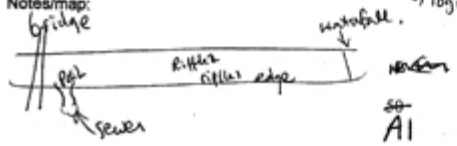
Group Name: One fish
Group Members: Julia, Victoria, Alex, Nicole

Date: Oct. 3, 2006
Time: 3-5 pm
Weather Conditions: rain in the morning (moderate for a few hours) sunny & warm while collecting
Dimensions of seine: 2m x 1m
Dimensions of dip net:

Sample number:	1	2	3	4	5	6
Gear Type:	seine	seine	dip net	seine	dip net	dip net
Habitat Type:	riffle	riffle	pool	pool	edge	riffle
Substrate Type:	rocky	rocky	silt/mud	silt/mud	mix of circles	rocky
Vegetation (y/n):	N	N	N	N	Y	N
Depth of river (m):	0.54	0.25	0.3	0.3	0.4	0.16
Current (ms^{-1}):	0.4	0.4	negligible	negligible	0.32	0.4
Temperature (°C):	15	18	17	17	18	18
Distance sampled (m):	2	2	2	2	3	2
Sampling time (min.):	2.0	2.5	2	1	2.5	2

Species abundance:					
Chinook salmon	none caught				none caught
River chub				1	
Creek chub				28	1
Hornyhead chub					
Common shiner	2	1	201		
Emerald shiner				3	
Johnny darter					
Rainbow darter	1				
Longnose dace	8				
Blacknose dace					
Fathead minnow					
Bluntnose dace					
Common carp					
Largemouth bass					
Rock bass					
Pumpkinseed			1	1	
Brook stickleback					
Bullhead catfish					
Stonecat catfish					
Northern hog sucker					
White sucker					
Round gobie	2				
Other	(1) log perch				

Notes/map:



Appendix B – see Excel file

Appendix C

Mean abundance (number/21600 s) of fish species sampled in three Habitats of the Humber River (at Etienne Brule Park, Toronto) on October 3 and October 10, 2006 using minnow traps.

Species	Pool	Edge	Riffle	Total
River chub	0.000	0.000	0.000	**0.000**
Creek chub	3.500	0.000	0.000	**3.500**
Hornyhead chub	0.000	0.000	0.000	**0.000**
Common shiner	8.500	4.750	0.000	**13.250**
Emerald shiner	0.000	0.000	0.000	**0.000**
Johnny darter	0.000	0.000	0.000	**0.000**
Rainbow darter	0.000	0.000	0.000	**0.000**
Longnose dace	0.000	0.250	0.000	**0.250**
Blacknose dace	0.000	0.250	0.000	**0.250**
Fathead minnow	0.000	0.000	0.000	**0.000**
Bluntnose minnow	0.000	0.000	0.000	**0.000**
Common Carp	0.000	0.000	0.000	**0.000**
Largemouth Bass	0.000	0.000	0.000	**0.000**
Rock bass	0.000	0.000	0.000	**0.000**
Pumpkinseed	6.500	0.750	0.000	**7.250**
Brook stickleback	0.000	0.000	0.000	**0.000**
Bullhead catfish	0.000	0.000	0.000	**0.000**
Stonecat catfish	0.000	0.000	0.000	**0.000**
Northern Hog Sucker	0.000	0.000	0.000	**0.000**
White Sucker	0.000	0.000	0.000	**0.000**
Log Perch	0.000	0.000	0.000	**0.000**
Other sp. (round goby)	0.000	0.000	0.000	**0.000**
Total	**18.500**	**6.000**	**0.000**	

Appendix D

The percentage distribution of species with tolerance to organic pollution, sediment and warm water for the years 2004, 2005 and 2006, as well as the data for the round goby.

Year	Intolerant	Moderately Tolerant	Tolerant	Round goby number/m^2
2006	9 (1 species)	25	66	0.100
2005	7 (1 species)	29	64	0.032
2004	6 (1 species)	31	63	0.000