AUSABLE RIVER FISHERIES SURVEY REPORT 2004

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Cover photographs credits: redfin shiner, hornyhead chub and longear sunfish (Shawn Staton, DFO); spotfin shiner and greater redhorse (Jamie Stewart, ABCA).

PREFACE

This report has been divided into two Parts. Part I of the report examines the fish communities and in-stream habitat characteristics of the Ausable River (wadeable sites). Part II of this report examines historical trends in the fishery of the Old Ausable Channel (non-wadeable sites).

PART I – AUSABLE RIVER

EXECUTIVE SUMMARY

The Ausable River Fisheries Survey was conducted during the summer and fall of 2004. A total of 32 sites were surveyed in the Ausable River basin. Fisheries information was collected using seining, backpack and boat electrofishing. Habitat characteristics, including total suspended solids, discharge, substrate particle size and embeddedness were surveyed at 19 sites upstream of the Highway 7 Sylvan Bridge to complement the fisheries information. These surveys were intended to identify habitat variables that affect fish community structure and to locate four Ausable River species at risk, including the black redhorse, river redhorse, eastern sand darter, and greenside darter. Identifying potentially limiting habitat characteristics for aquatic species at risk was determined to be a high priority in the Ausable River Recovery Strategy.

The greenside darter appears to be locally abundant in the Ausable River basin. Our findings suggest that this species prefers habitats with small pebble substrates, medium currents and moderately low substrate embeddedness. Greenside darters were present in very low abundances at sites with the highest suspended solids and substrate embeddedness.

The black redhorse and river redhorse were not located during the survey, although redhorse species diversity and abundance was high at some sites. Our study suggests that redhorse species generally prefer habitats with relatively low embeddedness, pebble-sized substrates, moderate flows, and less than 10% aquatic macrophyte cover. The absence of black redhorse in these reaches is likely related to the relative intolerance of this species to high-suspended solids and substrate embeddedness.

Total suspended solid concentrations appear to be related to the relative abundance of Cyprinidae and Centrarchidae species in the Ausable River. Sites exhibiting high concentration of total suspended solids generally have a high relative abundance of Cyprinids and low relative abundance of Centrarchids. Total suspended solid concentrations appear to play a substantial role in altering fish communities in the Ausable River, particularly during the summer months.

Identifying the current extent of range for the four species at risk fishes is an important first step in recovery actions for these species and the Ausable River ecosystem. The obtained knowledge of habitat preferences for species assemblages will further develop our understanding of the factors affecting species distribution in the Ausable River.

INTRODUCTION

Impacts from suspended and deposited fine sediment are often regarded as the principle factor in the degradation of stream and river fisheries (Alabaster and Lloyd 1983; Newcombe and Jensen 1996; Waters 1995; Wilber and Clarke 2001). The Ausable River Recovery Team identified siltation and turbidity as one of the primary threats to the health of aquatic species and habitat in the Ausable River (Nelson *et al*. 2003). The geology, vegetation and land-use of a watershed affect the amount of suspended solids discharged into a river. In the Ausable River, the majority of suspended solids and high turbidity are the result of clay soils, accelerated erosion from agricultural land, lack of natural cover and altered flow regime (Dolmage 2003; Environment Canada 2000).

When suspended sediments settle they may alter the riverbed. The settling sediment may stifle bottom-dwelling organisms, cover breeding areas, smother eggs, and fill interstitial spaces in the substrate (Allan 1995; Newcombe and MacDonald 1991). Aquatic species that are particularly sensitive to changes in their environment, or that have specific habitat requirements are most likely to be adversely affected by high-suspended solids (Gradall and Swenson 1982). The Ausable River Recovery Strategy describes four fish species listed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) that have been found in the main channel of the Ausable River that may be affected by the deposition of suspended sediment (Appendix 1).

1. black redhorse (*Moxostoma duquesnei*)
2. river redhorse (*Moxostoma carinatum*)
3. greenside darter (*Etheostoma blennioides*)
4. eastern sand darter (*Ammocrypta pellucida*)

These species at risk (SAR) fishes require areas with firm gravel or sand bottoms with moderate to swift currents. In particular, black redhorse, river redhorse, and the greenside darter prefer gravel substrates and the eastern sand darter is strongly associated with sand substrates (Nelson *et al*. 2003). Although their general habitat preferences are known, there was a lack of information about specific in-stream habitat preferences for these species, such as total suspended solid concentrations, flow regimes, and preferred substrate characteristics. This study therefore examined the distribution and abundance of fishes in the wadeable sections of the Ausable River basin in relation to environmental variables such as total suspended solids, substrate particle size, embeddedness, and discharge flow.

This study was intended to address three recommendations that were outlined as high priorities in the Ausable River Recovery Strategy (Nelson *et al*. 2003).

1. Investigate the relationships between species at risk and environmental variables:
    - identify threats which may be contributing to population limits or declines;
    - assess the importance of total suspended solids, discharge, and substrate characteristics in various fish communities; and
    - help to define critical habitat for SAR.

2. Conduct background surveys for aquatic SAR in the Ausable River basin:
   - help to define the extent and health of SAR populations;
   - develop baseline species-specific information for further recovery work;
   - help to define critical habitat for SAR; and
   - provide fish host information for freshwater mussel recovery work.

3. Develop a monitoring program to evaluate distribution and abundance of SAR:
   - initial development of a framework for a long-term monitoring program, use of effective sampling methods, site selection, etc;
   - help to define the extent and health of SAR populations; and
   - develop baseline species-specific information for further recovery work.

METHODS

Study Area

The Ausable River basin is located on the northern edge of the Carolinian Zone in southwestern Ontario (Figure 1). It is one of the most biologically diverse basins of its size in Canada (Nelson *et al*. 2003). Fish and habitat attributes were sampled at 19 locations above the Highway 7 Sylvan Bridge.

Habitat Characteristic Survey

A detailed site characteristics survey was conducted once a month, for five months between July and November 2004 for the 19 Ausable River fish survey sites upstream of the Highway 7 (Figure 1). The surveys were intended to relate site characteristics to the fish community. At each site, substrate particle size, substrate embeddedness and hydraulic discharge were recorded. Water temperature, conductivity, dissolved oxygen, pH, and total dissolved solids were measured with a calibrated YSI 650 MDS water probe.

Secchi depth was recorded to complement total suspended solid data as a measure of water turbidity. A water sample was taken at each site and analysed for total suspended solids concentration. Water samples were submitted to PSC Maxxam Analytical Services in London, Ontario for analysis. Analysis (non-filterable residue, gravimetric) was performed in accordance with the Protocol for Analytical Methods used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act to the nearest mg/L (APHA 1998).

Water discharge was quantified at a single cross-section of the river for each site. Water depth and current velocity were measured at 60% depths with a Montedoro-Whitney Model PVM-2A flow velocity meter and wading rod. Measurements were taken at evenly spaced intervals to ensure consistent and accurate results (Gore 1996). Interval spacing (1 or 2 m) was based on the relative width of the river at each site.

Figure 1. Ausable River Fish Survey Sites 2004

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The substrata were assessed at each site for particle size composition. Twenty random samples were taken and length, width, height (x,y,z) were measured to the nearest millimetre. Samples were taken from a cross-section of the river to ensure all areas/depths of the river were sampled to provide an accurate assessment of particle size composition at the site (Stanfield *et al*. 2001). Substratum particle sizes were assessed according to the Wentworth scale. The main disadvantage of this pebble count method is its inability to measure fine substrate particles less than 1.0 mm, however these substrates were accounted for as silt or sand and grouped as a single category for analysis.

Embeddedness was measured to assess the degree to which fine sediments surround coarse substrates on the surface of the streambed. Methods to measure embeddedness were taken from the U.S. Geological Survey National Water Quality Assessment Program (Fitzpatrick *et al*. 1998). Five gravel to boulder sized substrates were examined for embeddedness to the nearest 10% at three separate 1.0 m^3 transects. Transects were randomly placed at each site.

All site characteristics were measured during each of the five site surveys, with exception of substratum size composition, which was not measured during the November survey due to river conditions.

Results are reported as mean +/- one standard deviation. An analysis of variance (ANOVA) was performed spatially (across 19 survey sites) and temporally (five months) for total suspended solids, embeddedness, substrate particle size and discharge ($P<0.05$). T-tests were used to determine the differences between specific sites.

Fish Survey

The Ausable River fish survey was organized and conducted by the Ausable Bayfield Conservation Authority (ABCA) and the Department of Fisheries and Oceans Canada (DFO). The survey was conducted for 12 days between July 6 and July 23, 2004. A total of 32 sites were surveyed, which included 25 sites on the Ausable River main channel, three sites on the Ausable Cut, three sites on the Little Ausable River and one site on Nairn Creek (Figure 1). On the Ausable River, 19 sites were sampled upstream of the Highway 7 Sylvan Bridge and 13 sites were sampled downstream of the Highway 7 Bridge. At each site, GPS coordinates, location description, sampling method/details, catch data and landscape characteristics were recorded. Site photographs were taken and site maps were drawn at all locations to illustrate the particulars of each site. The fish catch data represents warm season conditions and may vary at other times of the year.

Fish survey sites were selected based on historical/incidental records, favourable habitat characteristics and accessibility. Survey sites were generally deemed as ‘wadeable’ sections of the river to ensure a thorough sampling and assessment of the site; a general summary of the sampling effort expended at each site is found in Appendix 2.

The Ailsa Craig area was heavily sampled in an attempt to locate a population of eastern sand darters (*Ammocrypta pellucida*). A historical fisheries record found an eastern sand darter in the Ausable River just west of Ailsa Craig (Hubbs and Brown 1929). Similarly, the only known record of the River Redhorse (*Moxostoma carinatum*) in the Ausable River was found in the Ailsa Craig area (Royal Ontario Museum 1936).

The Little Ausable River was sampled at three locations in an attempt to locate a black redhorse population. The first known record of a black redhorse was found in the lower reaches of the Little Ausable River during the 2002 ABCA/DFO fisheries survey. Other areas surveyed, included sites in the Ausable Gorge, Middle Ausable, Hay Swamp and the Ausable Headwaters. These sites were selected based on habitat characteristics that were deemed suitable for targeted species at risk (i.e., sand and rock substrates, swift currents, etc.).

The reach of the Ausable River from the Highway 7 Bridge downstream to the Bog Line crossing was heavily sampled in an attempt to locate river redhorse and the eastern sand darter. This area of the river had not been sampled extensively in recent years and the expected species at risk catch was largely unknown.

Three methods were employed to sample fish: backpack electrofishing, boat electrofishing and bag seining. Backpack electrofishing was used at 18 of the 32 survey sites and boat electrofishing was used at 11 of the 32 survey sites (Appendix 2). Sites were electrofished 435 to 3000 seconds depending on the river width, current and depth. Typically, electrofishing continued at each site until no new fish species were caught. Sites were surveyed in a systematic manner moving upstream from riffle to riffle. The electrofishing crew consisted of two netters and one electrofishing unit operator. The bag seine was used at sites with soft substrate and slow currents (10 of 32 sites) (Appendix 2). Sites with rocky substrate and fast currents hindered catch results. At favourable sites, between two and eight bag seine hauls were taken. Seines are extended perpendicular to shorelines and then swept in a 90˚ arc downstream to the shoreline. Bag seine crews consisted of two people working the wing guides/poles and one person maintaining the seine structure to school fish into the bag.

During processing (i.e., identifying, measuring and enumerating), fish were kept in a shaded large container that was actively aerated to maintain fish health. Fish were identified to species and measured for total length (to the nearest millimetre). Fish that could not be identified to species were preserved in formalin and returned to the Department of Fisheries and Oceans fish laboratory (Burlington, Ontario) for later identification.

Fish Community Data

Species richness, catch-per-unit-effort (C/*f*), and species diversity were assessed and compared at each survey site. The Shannon-Weiner Index of Species Diversity was used to enumerate species diversity:

$$H = \sum_{i=1}^{S} (Pi)(\log Pi) \quad Pi = Ni / N_{total}$$

Where:
H = species diversity
i = ranking of species
Ni = numbered of individuals of a species

Sampling effort varied considerably between two stretches of the Ausable River main channel. As a result, fish community data was pooled into two distinct datasets for analysis; sites upstream of Highway 7 at the Sylvan Bridge and sites downstream of Highway 7. In this report, the analysis and discussion of the Ausable River fish community is primarily focused on the sites upstream of the Highway 7 Bridge due to the greater sampling effort (Appendix 2).

The fish community was analysed with principle component analysis (PCA). PCA was used to summarize and describe sites based on fish family composition; it was performed with MiniTab Statistical Software (release 11.0 MiniTab Inc. 1996).

RESULTS

Habitat Characteristics

The main channel of the Ausable River has a number of unique habitats. The aquatic habitat changes from cool, clear headwaters at Staffa to the turbid and slow moving currents of the Hay Swamp, downstream to the fast moving rocky waters of the Ausable Gorge, and finally into the highly turbid and low gradient reaches of the Ausable Cut (Veliz 2001).

Although total suspended solids concentrations were not significantly different across the 19 sites in the Ausable River (P=0.054), some sites (i.e., Exeter, Little Ausable 2, and Little Ausable 3) appeared less turbid than sites in the Middle Ausable sub-basin (i.e., Glasgow and Island) (Table 1). Temporal differences in total suspended solid concentrations were significant (P=0.0015) with total suspended solids decreasing from summer to fall. From July to November the mean monthly total suspended solids decreased from 27.7 mg/L to 6.6 mg/L.

Table 1. Habitat Characteristic Summary for 19 Ausable River survey sites located upstream of the Highway 7 Sylvan Bridge.

Site Name	*Total Suspended Solids (mg/L)*	*Discharge (m3/sec)*	*Substrate Particle Size D50 (cm)*	*Embeddedness (%)*
Headwaters	6.0	0.0324	50.49	45.9
Exeter	1.2	0.1562	25.18	21.5
Hay Swamp	7.8	0.2692	0.06	100.0
Upper Ausable-Adare	8.8	0.3177	65.25	11.3
Ailsa Craig 1	9.8	0.6469	58.69	25.1
Ailsa Craig 2	10.2	0.6438	40.85	33.7
Ailsa Craig 3	14.4	0.7597	36.21	22.7
Ailsa Craig 4	11.2	0.5672	35.78	37.7
Ailsa Craig 5	17.4	0.7555	30.89	46.7
Middle Ausable-Nairn	15.8	1.0927	26.65	29.9
Middle Ausable-Glasgow	31.4	1.0170	38.43	25.7
Middle Ausable-Island	25.0	1.0359	24.72	29.3
Lower Ausable-Roddick	18.8	1.0746	58.14	18.1
Rock Glen	10.2	1.1755	121.43	16.7
Lower Ausable-Gorge	41.2	1.4233	39.41	52.9
Little Ausable 1	9.2	0.0140	48.54	43.1
Little Ausable 2	3.4	0.0180	121.32	10.4
Little Ausable 3	3.2	0.0787	92.40	25.6
Nairn	9.4	0.5783	47.63	30.4

Substrate particle size data were analysed to generate a D_{50} value for each survey site (Table 1). Substrate particle size was significantly different across all sites surveyed ($P=1.2\ E^{-83}$) (Table 2). Rock Glen, Little Ausable 2 and Upper Ausable-Adare had the highest D_{50} values, while Hay Swamp and Ailsa Craig 4 had the lowest.

Substrate embeddedness differed amongst the 19 sites evaluated ($P=7.6\ E^{-19}$) (Table 2). Embeddedness was highest in the Hay Swamp (100%). High embeddedness values were also found at Lower Ausable-Gorge, Ailsa Craig 5, Headwaters and Little Ausable 1. Conversely, Little Ausable 2, Upper Ausable-Adare and Rock Glen showed the lowest percentage of embeddedness (Table 1).

Discharge did not differ significantly among the 19 sites surveyed (P=0.074) (Table 2). However, a gradual increase in discharge was observed from the Headwaters sites to the Lower Ausable-Gorge (Table 1). Temporal differences in discharge were observed with low flows in July and August and higher flows in October and November.

Table 2. Statistical analysis summary for habitat characteristics at 19 survey sites upstream of the Highway 7 Sylvan Bridge on the Ausable River. Significance established at 95% confidence (P<0.05).

Habitat Character	Significance by Site	Significance by Month
Total Suspended Solids	**NO** P=0.054	**YES** P=0.002
Discharge	**NO** P=0.076	**YES** P=1.82 E^{-10}
Embeddedness	**YES** P=7.55 E^{-19}	Not Applicable
Substrate Particle Size	**YES** P=1.20 E^{-83}	Not Applicable

Fish Community

A total of 50 different fish species were caught during surveys of the 32 Ausable River main channel sites (Appendix 3). Six fish species were found in reaches of the Ausable River downstream of the Highway 7, which were not found at any sites upstream of the Highway 7 Bridge. Analysis of the Ausable fish community is primarily focused on sites upstream of the Highway 7 due to low sampling effort downstream of the bridge. Nineteen sites were located upstream of Highway 7 where total species richness was 44.

The average species richness at the sites upstream of Highway 7 was 16, with a maximum of 22 and a minimum of 9. Middle Ausable Island, Little Ausable 1, and Lower Ausable Gorge all showed high species richness. Low species richness was observed at Ailsa Craig 5, Little Ausable 3, Ailsa Craig 1. The average species diversity index across the wadeable Ausable main channel sites was 3.17, with a maximum of 3.87 and a minimum of 2.41. Middle Ausable-Island and Middle Ausable-Glasgow showed high species diversity, whereas Lower Ausable-Roddick and Ailsa Craig 5 showed low species diversity (Table 3).

Catch-per-unit-effort (CPUE) was calculated for each site based on the number of specimens caught and time electrofishing (in seconds) or number of bag seine hauls. Catch-per-unit-effort was used to determine the fish density for each site (Hall 1986). The highest density of fish was found at Little Ausable 1 for electrofishing (Table 3). These fish densities were more than two-times the density of any other site. Available electrofishing data suggested that Middle Ausable-Nairn and Ailsa Craig 5 had the lowest fish densities for sites upstream of Highway 7. Catch-per-unit-effort at Exeter, Hay Swamp, Ailsa Craig 4, and Lower Ausable-Gorge could not be determined because electrofishing and bag seine data was pooled, however we suspect that CPUE for these sites fall within this surveys CPUE range based on available effort and fish abundance data (Table 3). Average CPUE values for sites upstream of Highway 7 were found to be substantially higher than CPUE values for sites downstream of Highway 7.

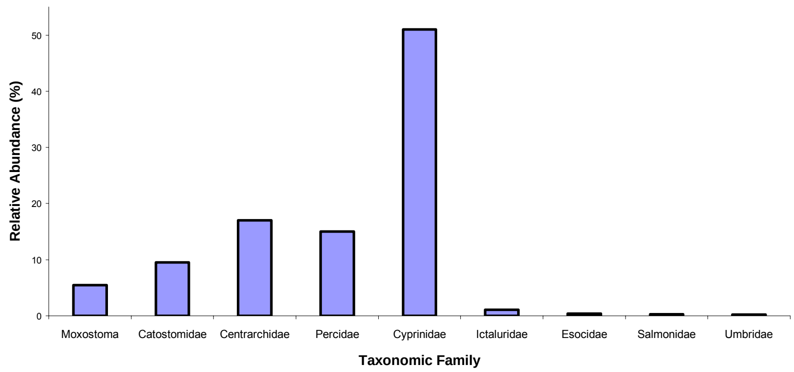
Table 3. Fish Community Biological Characteristic Summary for 19 Ausable River survey sites upstream of the Highway 7 Sylvan Bridge.

Site Name	*Fish Abundance at Site*	*Species Richness*	*Shannon-Weiner Diversity Index*	*Catch-per-unit-effort (per hour)*	*Catch-per-unit-effort (per haul)*
Headwaters	151	14	2.86	584.4	
Exeter	84	15	3.47	*	
Hay Swamp	99	13	2.58	*	
Upper Ausable-Adare	128	16	3.31	352.0	
Ailsa Craig 1	47	11	2.93	153.7	
Ailsa Craig 2	100	18	3.51	217.9	
Ailsa Craig 3	176	20	3.36	434.0	9.0
Ailsa Craig 4	109	14	3.02	*	
Ailsa Craig 5	36	9	2.58	135.4	
Middle Ausable-Nairn	53	18	3.56	112.4	
Middle Ausable-Glasgow	34	16	3.81	170.0	
Middle Ausable-Island	114	22	3.87	327.7	12.5
Lower Ausable-Roddick	141	13	2.41		17.6
Rock Glen	208	18	3.51	249.6	
Lower Ausable-Gorge	244	21	3.09	*	
Little Ausable 1	538	21	3.23	1832.6	46.0
Little Ausable 2	82	15	3.53	333.7	
Little Ausable 3	60	10	2.05	109.8	
Nairn	247	18	3.55	498.9	

* Catch-per-unit-effort could not be determined at these sites due to pooling of electrofishing and bag seine data.

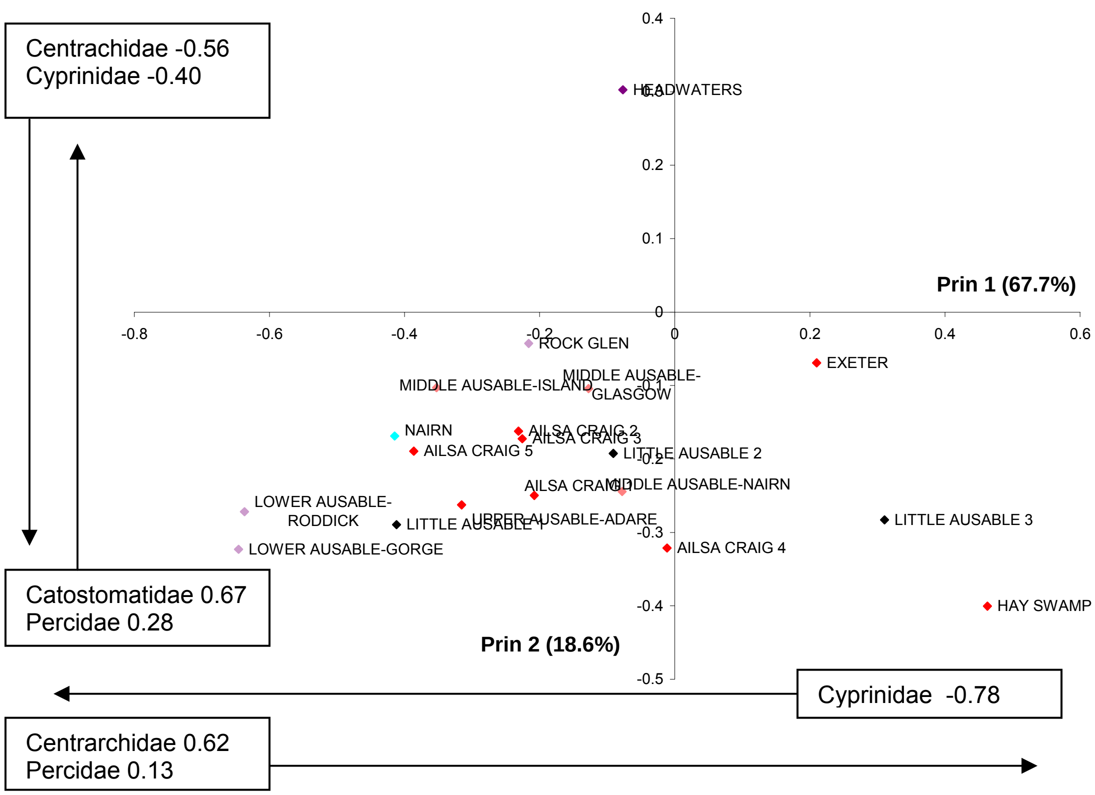
The 2651 fishes caught in the survey were grouped by taxonomic family and summarized to determine the general structure of the fish community in the Ausable River main channel (Figure 2). Cyprinidae (51% of fish caught) and Centrarchidae (17% of fish caught) were typically the most abundant families throughout the sites with few exceptions. At the Headwaters site Catostomidae dominated the fish community (54%). Exeter and Little Ausable 2 exhibited a high proportion of Percidae. Moxostoma were found in highest proportion at Ailsa Craig 1 (19%) and Middle Ausable-Glasgow (24%) (Appendix 4). The highest proportion of one fish family at a site was seen at Lower Ausable-Gorge (85% Cyprinidae) and Lower Ausable-Roddick (83% Cyprinidae). Hay Swamp showed a high proportion of Centrarchidae (77%). The Headwaters site exhibited a high proportion of Catostomidae (54%). No other site showed a Catostomidae percentage greater than 14% (Appendix 4).

Figure 2. The relative abundance of nine taxonomic fish families at 19 survey sites upstream of the Highway 7 Sylvan Bridge, in the Ausable River, 2004.



A principle component analysis of the relative abundance of major taxonomic fish families for each survey site suggested that fish community assemblages varied in the Ausable River (Figure 3). The fish communities of the Hay Swamp, Little Ausable 3, and Exeter differed from most sites based on the primary axis 1, which explains 68% of the variance. The high abundance of Centrarchidae appeared to separate these sites from the Cyprinidae dominated sites (Figure 3). The separation of Headwaters site from the other sites in primary axis 2 was due to the relatively high abundance of Catostomidae (eigenvalue of 0.67) at this site.

Figure 3. Ordination (PCA) of fish community assemblages in the Ausable River (2004). Taxa with high eigenvalues on both axes are indicated. The arrowhead indicates direction of increasing abundance.



Species at Risk

The greenside darter (*Etheostoma blennioides*) was the only species at risk caught in the main channel of the Ausable River, it was found to be one of the most common fish species caught throughout the survey. Greenside darters were found at 18 of 19 sites upstream of Highway 7, and were the most common species found with mimic shiners (*Notropis volucellus*) and rock bass (*Ambloplites rupestris*). The Headwater site was the only location where greenside darters were not found. A total of 242 greenside darters were captured during the surveys, which ranked third among the most numerous species caught. Only mimic shiners (n = 366) and rock bass (n = 278) were more abundant.

Fish and Habitat Relationships

Fish community differences amongst sites were best indicated by the relative abundance of Cyprinidae and Centrarchidae species (Figure 3). Habitat attributes (i.e., total suspended solids, discharge, embeddedness and substrate particle size) were evaluated with respect to these fish community indicators of Cyprinid and Centrarchid relative abundance. Although total suspended solid concentrations were not significantly different ($P<0.05$) at sites upstream of Highway 7, fish community data suggests that differences in total suspended solids may be an important determinant in explaining some of differences in the fish community structure. In particular, there appears to be some relationship between total suspended solid concentrations and the relative abundance of Cyprinidae and Centrarchidae species (Figure 4a and 4b).

Figure 4a. The relationship between the relative abundance of Cyprinidae species and total suspended solid concentration (mg/L) at 19 sites in the Ausable River upstream of the Highway 7 Sylvan Bridge, 2004.

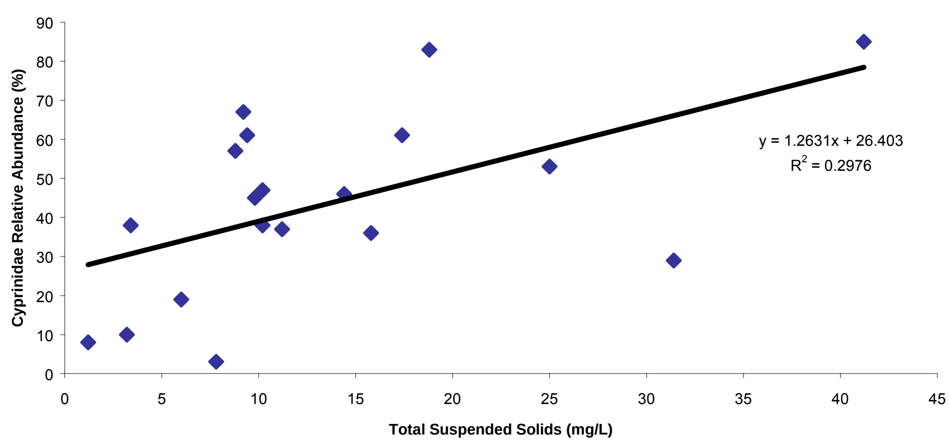
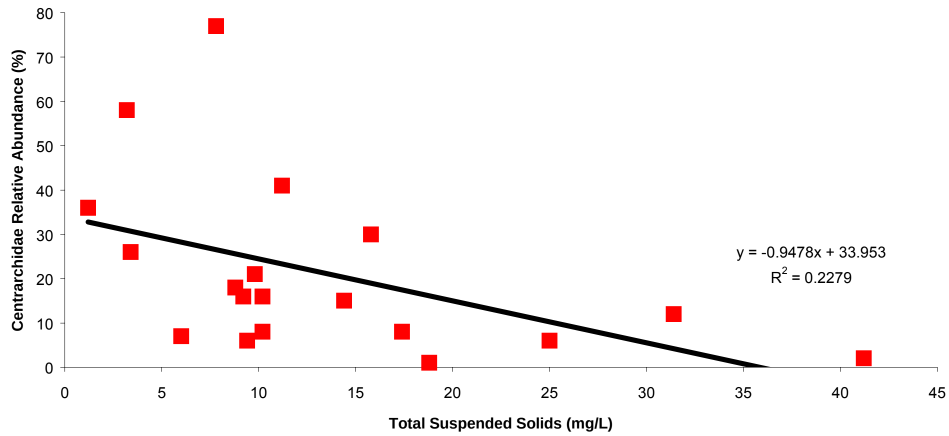


Figure 4b. The relationship between the relative abundance of Centrarchidae species and total suspended solid concentration (mg/L) at 19 sites in the Ausable River upstream of the Highway 7 Sylvan Bridge, 2004.



Although substrate size and embeddedness differed amongst sites (P=1.20 E^{-83} and P=7.55 E^{-19}, respectively), these factors did not appear to contribute to the relative abundance of Cyprinids or Centrarchids at the survey sites (Table 4). As such, total suspended solid concentrations appear to the main habitat variable that determines the relative abundance of Cyprinids and Centrarchids in a fish community in the Ausable River.

Table 4. Statistical trend analysis summary for embeddedness and substrate particle size at 19 survey sites upstream of the Highway 7 Sylvan Bridge on the Ausable River.

Habitat Character	Equation	R^2 value
Embeddedness	Cyprinid rel. abundance = - 0.1093 embeddedness + 51.40	**0.0224**
	Centrarchid rel. abundance = 0.0794 embeddedness + 13.92	**0.0245**
Substrate Particle Size	Cyprinid rel. abundance = 0.4349 substrate size + 32.83	**0.0597**
	Centrarchid rel. abundance = - 0.2682 embeddedness + 26.01	**0.0469**

DISCUSSION

Fish Community

The fish community of the Ausable River main channel showed high species richness and diversity (Table 3). Forty-four different fish species were found throughout the 19 survey sites upstream of the Highway 7 Bridge (Appendix 3). Overall, the Ausable main channel fish community is dominated by Cyprinid species. Survey sites typically exhibited a fish community structure that was approximately 50% Cyprinids, 20% Centrarchids, 15% Percidae, and 15% Catostomidae/Moxostoma (Figure 2). The Ausable River has a highly diverse fish community that is able to partition and utilize specific habitats and resources. Some sites, such as the Headwaters, Hay Swamp, and Little Ausable 3 showed considerable variation from this typical fish community structure (Appendix 4).

Hay Swamp and Little Ausable 3 were dominated by Centrarchids (>55%) and had Cyprinid populations of less than 15%. These findings may be the result of increased vegetation growth due to low total suspended solids (<7.8 mg/L). High levels of suspended solids can diminish the growth of aquatic plants by reducing light penetration that is needed for plant photosynthesis. Centrarchids readily utilize aquatic plants as cover and refuge from water currents in lotic environments (Paragamian 1991). Furthermore, Buck (1956) documented that Centrarchidae production is related to suspended solid concentration; production increases with decreasing total suspended solid concentrations (Table 5).

Table 5. Centrarchidae fish production in response to elevating total suspended solid concentrations.

Total Suspended Solids	Centrarchid Yield
< 25 mg/L	181.0 kg/ha
25 – 100 mg/L	105.4 kg/ha
> 100 mg/L	32.8 kg/ha

* modified table from Buck 1956 *In* Kerr 1995

Furthermore, Mraz (1964) noted that smallmouth bass habitat and spawning grounds are adversely susceptible to siltation caused by elevated suspended solids. Paragamian (1991) reported smallmouth bass were not found in silt-laden reaches where cobble or boulder substrates are absent and sand substrates are dominant.

Although, total suspend solid concentrations were not significantly different among our survey sites above Highway 7, the fish communities appear to have responded to subtle differences in water turbidity (Figure 4a and 4b). Ausable fish communities with large proportions of Cyprinidae species appear to be correlated with higher levels of total suspended solids, whereas fish communities with large proportions of Centrarchidae species appear to be correlated with lower concentrations of total suspended solids.

The reduced Cyprinidae population at sites with low suspended solids may also result from comparatively high predation on Cyprinids by other predatory fish. At sites with high-suspended solids, reduced light penetration can affect the sight of feeding fish by reducing their ability to locate prey (Bruton 1985; Zettler and Carter 1986). As a result, turbidity can reduce the feeding of predatory fish even when food is abundant (Gregory 1991; Vinyard and O'Brien 1976). Furthermore, Heimstra et al. (1969) reported that in sites with high turbidity, some Centrarchidae social hierarchies were disturbed and territories were not defended. These findings suggest that suspended solids may be a limiting factor for Centrarchidae distribution in the Ausable River main channel.

The Catostomidae family dominated the Headwaters site, contributing 54% of the fish community (Appendix 4). This site exhibited highly variable habitat having some cobble-based shallows, but also having some deep (>2.0 m) silt covered holes with thick submergent macrophytes. Catostomids were concentrated in these deep pools and we suspect ample food supply, and refuge from predators played a major part in this congregation. Centrarchids and other predatory fish were found in small numbers (7%) at this site, which would suggest a reduced predation rate on Catostomids. The deep pools and thick aquatic macrophytes would also allow Catostomids to escape predatory birds. Many Catostomids are moderately active during the day and move into shallower water during sunrise and sunset to feed (Scott and Crossman 1998). The presence of thick aquatic vegetation and the gradient between the deep pools and shallows would be favourable for Catostomidae feeding at this site.

Approximately 5.5% of the fish caught during the Ausable River main channel survey were Moxostoma species. Black redhorse (*Moxostoma duquesnei*) and river redhorse (*Moxostoma carinatum*) were two of the listed species at risk targeted in the Ausable River main channel. These species at risk were not found, however four other Moxostoma species were caught during the survey. The capture of these other Moxostoma species suggest that there may be favourable habitat for the black redhorse and river redhorse in the Ausable main channel even though they were not found during this survey.

Moxostoma species were most common in run-pool areas directly downstream of substantial riffles. Middle Ausable-Glasgow and Ailsa Craig 1 showed the highest percentages of Moxostoma at 24%, and 19%, respectively. These sites both had embeddedness values of 25-26%, mean D_{50} substrate sizes greater than 29mm, and mean hydraulic discharges that were above average throughout our sites and study period. These findings indicate that Moxostoma species prefer habitats with relatively low embeddedness, pebble substrates (according to the Wentworth Scale), moderate flows, and less than 10% aquatic macrophytes cover. Cooke and Bunt (1999) reported pre-spawning habitat use for Greater Redhorse (*Moxostoma valenciennesi*) and Golden Redhorse (*Moxostoma erythrurum*) was concentrated in areas with relatively unembedded cobble to pebble substrates, moderately swift flows and sparse aquatic macrophytes.

Golden redhorse were one of the most common species caught during the survey (13 of 19 sites). This finding is of particular interest because golden redhorse are frequently found in the same habitat as black redhorse over much of their ranges (Kwak and Skelly 1992). No black redhorse were found during these surveys, however the established golden redhorse population suggests that black redhorse may still be living in the Ausable River. These findings also indicate that there may be some underlining causes for the abundance of golden redhorse and the apparent lack of black redhorse. Kwak and Skelly (1992) developed habitat-use curves and found that black redhorse spawned in habitat that was slightly deeper, much swifter, and over coarser substrate than that of the golden redhorse. Substrate embeddedness may also play an important role in the lack of black redhorse and abundance of golden redhorse in the Ausable main channel. Golden redhorse appear to have the ability to withstand higher levels of substrate embeddedness and less coarse substrate than the black redhorse. Meyer (1962) noted that golden redhorse and silver redhorse are better able to cope in habitats with slower currents and higher suspended solids.

This type of species-habitat association for Moxostoma species is important for determining suitable habitat and future sampling locations for Moxostoma species at risk in the Ausable River. Based on our findings and the historic records, it is likely that black redhorse still exist in the Ausable River in limited numbers, although their presence was not verified in this study.

Species at Risk

Greenside darters (*Etheostoma blennioides*) exist in only a few watersheds in Canada and are listed as a 'special concern' species by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). Greenside darters were the only species at risk found during the 2004 Ausable River main channel survey.

In order for the Species at Risk Act to achieve its goals, Poos *et al.* (2004) suggested that Species at Risk fish recovery should be based on interspecific habitat preferences. Previous information suggests that greenside darters are specialized with respect to food, habitat and breeding areas. They are commonly found in rivers and streams with moderate to fast moving currents and low turbidity (Dalton 1991). Abundance tends to be greatest in shallow, swift riffles with a substrate composed of rubble and boulders (Englert and Seghers 1983; Chipps and Perry 1994). Critical habitat of the greenside darter is their spawning areas, which is characterized as riffles with filamentous algae covering the rocks (Scott and Crossman 1998). More specifically, Bunt et al. (1998) noted that greenside darters prefer riffle habitats that consisted of cobble with large mats of *Cladophora*. They require consistent and moderate flows to maintain their unembedded riffle habitat for spawning.

There is much general habitat and species information available on the greenside darter, however little of this information involves analysis of water quality (i.e., total suspended solids), substrate composition, and discharge data. Both new data and historic information were used to generate a more accurate assessment of interspecific habitat preferences for the greenside darter in the Ausable River.

Greenside darters appear to be locally abundant in the Ausable main channel, accounting for approximately 9% of fish caught during sampling. This may be the result of favourable spawning, nursery and feeding habitat. Cobble substrates and filamentous algae cover are common in most riffle areas upstream of the Highway 7 Bridge in the of the Ausable main channel. When habitat characteristics are compared across all our sites, some general consistencies amongst habitat types for greenside darters appear. In particular, Ailsa Craig 3 and Ailsa Craig 5 had greenside darters making up greater than 25% of the fish community. These sites exhibited average survey values for total suspended solids (15.9 mg/L) and embeddedness (35%), whereas substrate particle size (20.8 mm) was below average and discharge (0.76 m^3/sec) was above average. Greenside darter abundance was low or absent at the Headwaters and the Hay Swamp, which exhibited average survey values for embeddedness (34%) and below average values for substrate particle size (37.8mm), total suspended solids (3.6 mg/L), and discharge (0.09 m^3/sec). Low discharges at these sites are likely the limiting factor for the greenside darter. Our findings suggest that greenside darters prefer habitats with small pebble substrates, medium currents and moderately low substrate embeddedness.

Although greenside darter populations in the Ausable River appear to be abundant and stable, some research suggests that changes in river sediment and substrate would likely have serious impacts on the greenside darters (Dalton 1991; Chipps and Perry 1994). Dalton (1991) indicated that even minor changes in habitat would likely reduce populations. These ideas may be illustrated at the Lower Ausable-Gorge site, which had the lowest proportion of greenside darters present and also had the highest total suspended solids (41.2 mg/L) and one of the highest levels of substrate embeddedness (53%).

The only site where greenside darters were not found was the Headwaters. This is likely due to variable habitat conditions and competition from the abundance of darter species at this site, four species comprising 20% of the fish community. Hlohowskyj and Wissing (1985) suggested that greenside darters are rarely found in headwater habitats during summer months due to their vulnerability to changing environmental conditions. Their findings indicated that greenside darters were unable to withstand elevated water temperatures, in the same way which rainbow and fantail darters can. These elevated water temperatures are commonly associated with open, unshaded headwater streams during summer months, which in-turn would restrict greenside darters to cooler, more thermally stable conditions. As well, Bunt et al. (1998) indicated that greenside darters were not commonly found in areas used by other darters in the Grand River. We suspect high darter competition for limited resources and fluctuating habitat conditions at this site played a role in the absence of greenside darters.

Another reason explaining the dominance of greenside darters may be due to sampling biases during the survey. Shallow stretches (<2.0 m) of the Ausable River between riffles were targeted to achieve a thorough sampling of sites. These shallow riffle areas tend to be favourable habitat for greenside darters, and as a result, our counts may be artificially elevated across the Ausable main channel surveys. Nevertheless, our results do indicate healthy populations and we suspect greenside darters are locally abundant within the Ausable River basin due to favourable spawning, nursery and feeding habitat.

Habitat and Substrate Composition

The diversity of substrate types and sizes can often be linked to the diversity and abundance of fauna in rivers (McCubbin *et al.* 1990). Substrate particle sizes were generally medium sized in the Ausable Headwaters, very fine in the Hay Swamp, moderately large through the Upper Ausable River, small through the Middle Ausable – Ailsa Craig area, large through the Ausable Gorge, and small again downstream of the Gorge in the Lower Ausable. Conversely, percent embeddedness generally corresponds in the opposite manner, such that where particle size was low, embeddedness was high. Total suspended solids often have an impact on the relationship between substrate particle size and embeddedness in aquatic environments.

In general, our survey indicated that total suspended solid concentrations increase downstream to the Ausable Gorge (at Rock Glen), where suspended solid concentrations decrease presumably due to the increase in the river gradient, flows and tributary inputs. Changes in total suspended solid concentrations throughout the Ausable River basin are also likely due to changes in the natural subsurface geology, such as soil type and texture (Veliz 2001).

Significant increases in suspended solids were observed in Hay Swamp and in the Glasgow Road area. Total suspended solids were also found to decrease by close to 50% from the end of July to the end of August, and values continued to decrease from August to November in 2004. These changes in turbidity may be the result of decreasing water discharge in the river as the summer progresses into the fall, which would cause suspended sediment to settle to the riverbed. Alternatively, large phytoplankton and zooplankton communities may contribute to the total suspended solids in the Ausable River. Cooling water temperatures in the fall may cause a substantial die-off of these plankton communities, which would decrease turbidity in the river.

The Ausable River Recovery Team identified siltation and turbidity as one of the primary threats to the health of aquatic species and habitat in the Ausable River (Nelson *et al*. 2003). These threats are strongly correlated with in-stream environmental variables such as total suspended solids, substrate particle size, and embeddedness (Waters 1995).

The main channel of the Ausable River had relatively high levels of suspended solids. Historical data has shown that these elevated turbidity levels may be the result of clay soils, lack of natural cover, altered flow regime, and high erosion due to drainage and heavy precipitation (Dolmage 2003; Nelson *et al.* 2003).

Environment Canada's Riparian Habitat Guidelines for the Great Lakes area indicates that suspended sediment concentrations should remain below 25 mg/L in order to sustain no harmful effects to the local biota (Environment Canada *et al.* 1998). Various aquatic studies support this guideline and further suggest that a reasonably good fishery may be maintained for suspended sediment concentrations between 25 mg/L and 80mg/L. Higher concentrations even over a short period of time may have serious detrimental effects on aquatic habitat and species (Alabaster and Lloyd 1983; Gartner Lee Limited 1997; Newcombe and MacDonald 1991). The highest recorded total suspended solid concentration during the survey was 156 mg/L at the Lower Ausable-Gorge site in July. Although not common, these periodic events of highly elevated suspended solid concentrations do occur in the Ausable River and likely do considerable damage to the aquatic ecosystem.

Our findings indicated that average suspended solid concentrations in the Ausable River remained less than 41 mg/L across all our survey sites. It is important to note that although this average value falls in the range where a reasonably good fishery may be maintained, average suspended solid concentrations often exceeded Environment Canada's guidelines. In particular, through the month of July suspended solid concentrations were consistently higher than 25 mg/L, which suggests that aquatic biota are may experience some harmful effects due to siltation and turbidity.

Sediment-associated physical factors can inhibit the reproduction, growth, behaviour, and competitive ability of many aquatic species. Siltation in aquatic habitats is known to reduce the abundance of fish abundance and species diversity. When the water slows down, the suspended sediment settles and drops to the bottom and as the silt or sediment settles it may change the river bottom. The settling silt may smother bottom-dwelling organisms, cover breeding areas, smother eggs, and fill substrate interstitial spaces (McCubbin *et al.* 1990). Indirectly, the suspended solids affect other parameters such as temperature and dissolved oxygen. Because of the greater heat absorbency of the particulate matter, the surface water becomes warmer and this tends to stabilize the stratification (layering) in stream pools, bays, and reservoirs. This, in turn, interferes with mixing, decreasing the dispersion of oxygen and nutrients to deeper layers (Newcombe and MacDonald 1991). Berkman and Rabini (1987) noted that siltation inhibits feeding in golden redhorse, and likely other redhorse species. The Lower Ausable-Gorge site had the highest mean total suspended solid concentration at 41.2 mg/L, however 7% of the fish community was found to be Redhorse species. We suspect that the total suspended solid concentrations were not high enough to significantly alter the Moxostoma fish community during our sampling period (July – November).

CONCLUSIONS

The fish community and aquatic habitat of the Ausable River is highly variable and diverse. Specific habitat characteristics contribute to the fish community structure in different areas of the river. In particular, total suspended solid concentrations appear to be related to the relative abundance of Cyprinidae and Centrarchidae species in the Ausable River. Sites exhibiting high concentration of total suspended solids generally have a high relative abundance of Cyprinids and low relative abundance of Centrarchids. Conversely, sites with low concentrations of total suspended solids have a high relative abundance of Centrarchids and a low relative abundance of Cyprinids.

Moxostoma species are not uncommon in the Ausable River due to its favourable habitat, such as relatively low embeddedness, pebble substrates, and moderate flows. Moxostoma species richness is high in the Ausable River, which suggests that they likely segregate and utilize specific habitats. The targeted black redhorse and river redhorse were not located in this survey, although we suspect that this species do still exist in small numbers within the Ausable River basin.

Greenside darter populations of the Ausable River basin appear to be abundant and stable. Our findings suggest that greenside darters prefer habitats with small pebble substrates, medium currents and moderately low substrate embeddedness.

Total suspended solid concentrations appear to play a substantial role in altering fish communities in the Ausable River, particularly during the summer months. Species at Risk in the Ausable River are particularly sensitive to sediment-associated changes in habitat, such as increased siltation, embeddedness, turbidity, and substrate size. Siltation and turbidity are considered the primary threats to the health of aquatic species and habitat in the Ausable River.

RECOMMENDATIONS

1. There is a need to conduct a quantitative aquatic habitat assessment of the Ausable River. This type of information will further identify favourable sampling locations for Species at Risk fishes, as well as provide baseline aquatic habitat information about the Ausable River.

2. An assessment of the plankton community in the Ausable River from July to November would establish the proportional component of phytoplankton and zooplankton that are contributing to total suspended solid levels. This may also help address the reasons why total suspended solid concentrations decrease so drastically during the fall.

3. Further sampling is required in the Upper Ausable, Middle Ausable and the Little Ausable River for black redhorse. These areas have been identified as the most probable locations were black redhorse could be found and it is likely that a some still exists in the Ausable River. It is recommended that some sampling be conducted in the spring (spawning season), when black redhorse activity is high in shallow riffle areas and it is likely that movement begins to decrease as water temperature and total suspended solid level increase in the summer.

4. Further sampling is required in the Hay Swamp and Ailsa Craig area for the eastern sand darter, although it is likely that this species is extirpated from the Ausable River (last confirmed specimen was caught in 1929). The habitat of the Ausable River is changing and highly diverse, therefore it is probable that the river has transformed considerably over the past 75 years. If suitable habitat is identified, it is likely that it would be able to sustain a viable population of eastern sand darters.

5. Greenside darter populations appear to be healthy and widespread in the Ausable River. The Ausable River Recovery Team should take this knowledge in account in future revisions to the Ausable River Recovery Strategy. This species could likely be considered for down listing within the Ausable River and take on a lower priority in recovery efforts.

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