FISH COMMUNITIES OF THE ST. MARY'S RIVER WATERSHED:

AN ANALYSIS OF COMMUNITY DIVERSITY AND STRUCTURE.

Sean C. Mitchell, M.Sc., PhD
Waterways Environmental Services

February 6, 2012

St. Mary's River Association Technical Report #014

SMRA
St. Mary's River Association

ACKNOWLEDGEMENTS

This analysis was made possible through funding provided by Sage Environmental Program to the St. Mary's River Association (SMRA). The SMRA is grateful to this program for providing financial resources allowing this analysis. Further, this analysis would not have been possible without contribution of data from the Department of Fisheries and Oceans (DFO; Maritimes Region) and Nova Scotia Department of Fisheries and Aquaculture (NSDFA). The DFO dataset was provided courtesy of Dr. Jamie Gibson (DFO Science, Bedford Institute of Oceanography, Dartmouth, NS) and NSDFA data courtesy of John MacMillan (cold water fish biologist, NSDFA, Pictou, NS). We acknowledge these individuals and agencies and thank them for providing the raw data allowing this analysis.

Disclaimer: The data for this analysis was provided by DFO and NSDFA, but the analysis, results and interpretation are those of the author alone.

EXECUTIVE SUMMARY

Fish community composition is a useful indicator of environmental conditions. There is considerable variation in environmental conditions in a watershed in spatial and temporal dimensions, and the effects of this variation on community composition are of interest to understand community stability over space and time. The purpose of the work described here was to identify areas in the watershed in which community structure is unusual, and highlight these areas for future work. The St. Mary's River drains a large watershed in northeastern Nova Scotia and has an extensive electrofishing dataset. These data sets come from the Department of Fisheries and Oceans and Nova Scotia Department of Fisheries and Aquaculture and consisted of more than 100,000 records of individual fish from 33 systems (tributaries or mainstem locations) over 31 years. Two limitations were identified with the data : (1) not all fish were identified to species but a large fraction only identified to family, and (2) there was variation in electrofishing effort and distribution of effort among methods. Species richness was calculated as the sum of individual species, diversity calculated as Shannon-Weiner diversity index (H'), and Evenness as the proportion of observed diversity to maximum possible diversity.

There are 20 positively identified fish species from 11 families in the St. Mary's River with the most abundant being Atlantic salmon, American eel, white sucker, and brook trout. There is no evidence of consistent differences in species richness between or among branches. Typical species richness in a sample is 3 or 4 species. Diversity is, on average, less in the East Branch than West, shows similar variation among systems within these two branches, and does not indicate directional change (trend) over time. Evenness is statistically lower in the East Branch than the West Branch, suggesting a more even contribution by community members in the West than East Branch. However, this is a statistical difference, it is unlikely to be ecologically meaningful. The variation in evenness among systems within a branch is low.

The richness of the St. Mary's River is typical of Nova Scotia, which is depauperate relative to more continental systems, but more species rich than truly insular systems. Numerically dominant species (Atlantic salmon, American eel, white sucker, brook trout) are consistent with other studies in Atlantic Canada. West Branch Shannon-Weiner diversity is of slightly greater diversity than the East Branch, though variation among tributaries within a branch is similar between the East and West Branches. There is no evidence of areas within the St. Mary's River of consistently lower (or greater) diversity than others. Further, there are no obvious trends over time indicating either increasing or decreasing diversity. Rather, diversity appears to be stable over the long-term. These communities are clearly dominated by few widespread species (salmon, eel, sucker, trout) and the number of members in the community is small. The observed relatively high values of evenness are likely accounted for by the ubiquitous and common species of salmon, eel, sucker and trout.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1.0 INTRODUCTION

Fish community composition (i.e., species presences and relative abundance) is a useful indicator of environmental conditions in which the community exists. Species richness (number of individual species) and diversity (number of species and number of individuals per species) provides information on general conditions by assessing whether certain species are favored over others or dominant species are lacking at specific areas. Considerable environmental variation exists among locations in a watershed due to land use, water chemistry, and local site specific influences. Further, there is temporal variation at a given site as conditions fluctuate and change from year to year. The effects of this spatial and temporal variation are as interesting, if not more so, than the "average" condition as areas of large variation are less stable or predictable that those areas of lower variation. Thus, variation may be used to assess constancy of conditions for fish presence and relative abundance in the community. Similarly, variation over time can be very instructive to identify locations of low constancy, and from there assess the reason for this. However, to conduct a comprehensive spatial and temporal analysis requires a large dataset of fish presence. This requirement is met by a long-term Department of Fisheries and Oceans (DFO) electrofishing program in the St. Mary's River, consistently sampling between 7 and 46 sites per year in 31 years between 1969 and 2010. Further, the Nova Scotia Department of Fisheries and Aquaculture (NSDFA) has also conducted limited electrofishing in the St. Mary's River, contributing further data.

These data from DFO and NSDFA are used here to conduct spatial and temporal analysis of species richness and diversity within the St. Mary's River. The purpose of this work is to identify areas in the watershed in which community structure is unusual, and highlight these areas for further work. This work is part of a larger project which included a similar analysis of fish size-at-age and growth (see SMRA Technical Report #15: *Salmonids of the St. Mary's River watershed (I): A temporal and spatial analysis of size and growth*)

2.0 STUDY AREA

The St. Mary's River, Guysborough County, drains an area of approximately 1,350 km^2, flowing into a flooded-river-valley type estuary at Sherbrooke, Nova Scotia (45°08'00"N, 61°59'01"W). This river is a large system with a mean annual flow of 45.6 m^3/s at Stillwater (Mitchell, 2009) and includes an estimated 118[1] tributaries ranging from 1st to 4th order and 132 lakes. Elevations within the watershed range from 0 m (sea level) to 260 m.

There are three major branches to the St. Mary's River (Figure 1):

(1) The East Branch extending from the headwaters of Moose River, Garden River and Eden Lake to Glenelg (27 km long; drainage area 389 km^2). Communities along the East Branch include Garden of Eden, Willowdale, East River St. Mary's, Newtown and Denver. This branch contains 27 streams and 43 lakes.

(2) The North Branch (Lochaber, Lochiel and Wallace lakes; 27 km long; drainage area 82 km^2). This branch contains 27 streams and 14 lakes.

[1] 11 of these tributaries are on the Main Branch, below the confluence of the East and West Branches at Glenelg, and so outside the scope of this report.

(3) The West Branch extending from the headwaters near Trafalgar (Nelson and North Nelson Rivers) to Glenelg (56 km long; drainage area 470 km^2). Communities along the West Branch include Cameron Settlement, Caledonia, Lower Caledonia and Smithfield. This branch contains 53 streams and 57 lakes.

Electrofishing has been conducted throughout the watershed in various years between 1969 and 2011 (See *Materials and Methods* for details). Only data to 2010 is included here as at the time of data analysis, the 2011 data was not yet finalized.

3.0 MATERIALS & METHODS

3.1 DATA SOURCES:

Electrofishing data for this community composition analysis came from two sources. The Department of Fisheries and Oceans has data for up to 31 years between 1969 and 2010 on 27 "systems" (systems defined here as tributaries or river mainstem) of which 9 are on the East Branch, 2 on the North Branch, and 16 on the West Branch, (Table 1; Figure 1; Figure 2). The number of years sampled per system ranged between 1 and 31 years, with 16 systems sampled in 7 or fewer years, 11 sampled for 14 or more years and zero sampled between 7 and 14 years (Table 1). This dataset consisted of 115,007 records of individual fish. As the data were collected over a long period with varying levels of effort and purposes of data collection, various methods were used (e.g., number and timing of passes; see *Sampling Methodologies* below). Further electrofishing data for the St. Mary's River was provided by the Nova Scotia Department of Fisheries and Aquaculture. These data consisted of two years of record, 2003 and 2005, for 15 systems – 14 on the West Branch and 1 on the East Branch (Table 1; Figure 1). The dataset included 668 records of individual fish.

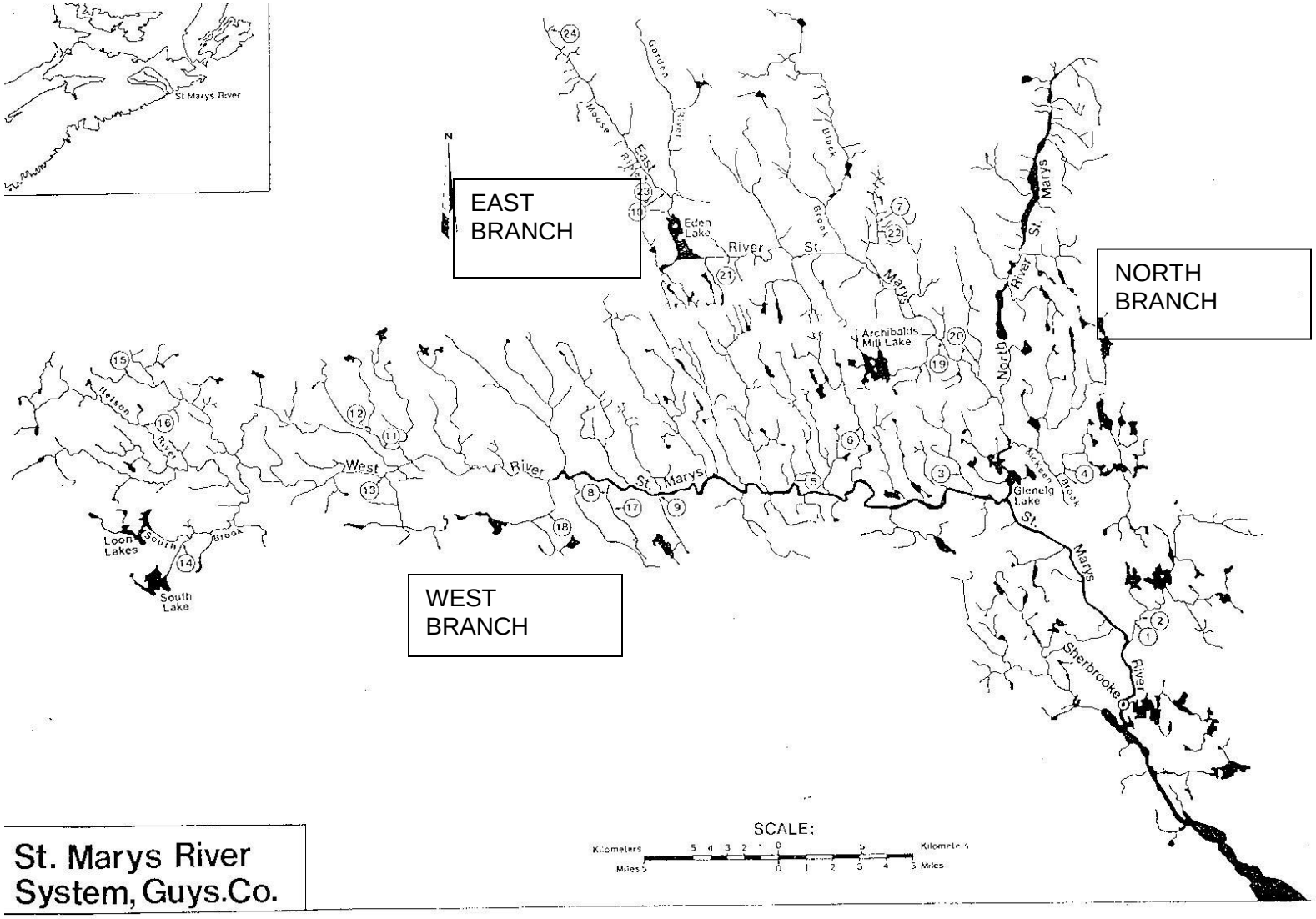

Figure 1: St. Mary's River watershed illustrating four "branches" of river. Circled numbers are electrofishing sites, but does not include all those used here. Numbered sites are cross-referenced to Table 1 for identification. (Figure modified from Mitchell, 2011)

Table 1: Number of years and methods used for 33 systems (individual brooks or mainstem rivers) for St. Mary's River from DFO and NSDFA electrofishing database. NSDFA samples indicated in parentheses. Methods are Mark-Recapture (MR), Multiple Pass (MP) or One-Pass (OP). Numbered site locations shown in Figure 1 are identified here. Not all system sampled numbered in Figure but unnumbered sites may be interpolated as systems placed in order of downstream to upstream

System	Number of sites in system	Number of years sampled	Sampling method (DFO only)	DFO electrofishing site numbers from Figure 1
EAST BRANCH (n=9)				
East River St. Mary's mainstem	13	22	MR; MP; OP	19, 21
McKeen's Brook	3	26	MR; MP; OP	4
Big Meadow Brook	2	5	MR	20
Archibald's Mill Brook	(1)	(1)		
MacKay Brook	3	7	MR	7, 22
Black Brook	1	2	MP	
Campbell Brook	1	2	MP	
Garden River	2	6	MP	
Moose River	7	26	MR; MP; OP	10, 23, 24
NORTH BRANCH (n=3)				
North Branch mainstem	1	4	MP; OP	
Bogg's Brook	1	1	MP	
McNab's Brook	2	2	MR; MP	
WEST BRANCH (n=21)				
West River St. Mary's mainstem	17	31	MR; MP; OP	13
Archibald's Brook	9	14	MR; MP; OP	3
McLeod Lake Brook	(1)	(1)		
Glencross Brook	5 (1)	6 (1)	MR; MP; OP	6
Clark Brook	1 (1)	1 (1)	MP	
Indian Man Brook	1 (1)	20 (1)	MR; MP; OP	5
MacDonald Brook	2 (1)	2 (1)	MP; OP	
Sutherland's Brook	(1)	(1)		
MacDonald Mill Brook	(1)	(1)		
Barren Brook	3 (1)	14 (1)	MR; OP	
Kelly Brook	1 (1)	2 (1)	MR	9
Mitchell Brook	3 (1)	21 (1)	MR; OP	8, 17
Cross Brook	(1)	(1)		
Chisholm Brook	1 (1)	3 (1)	MR; OP	18
Bryden Brook	2	3	MR	11
Middle Bryden Brook	1	3	MR	12
Long John (Black) Brook	(1)	(1)		
Castley Brook	2	1	MR	15
South Brook	3	19	MR; MP; OP	14
Nelson River	3 (1)	17 (1)	MR; MP; OP	
North Nelson River	6	16	MR; MP	16

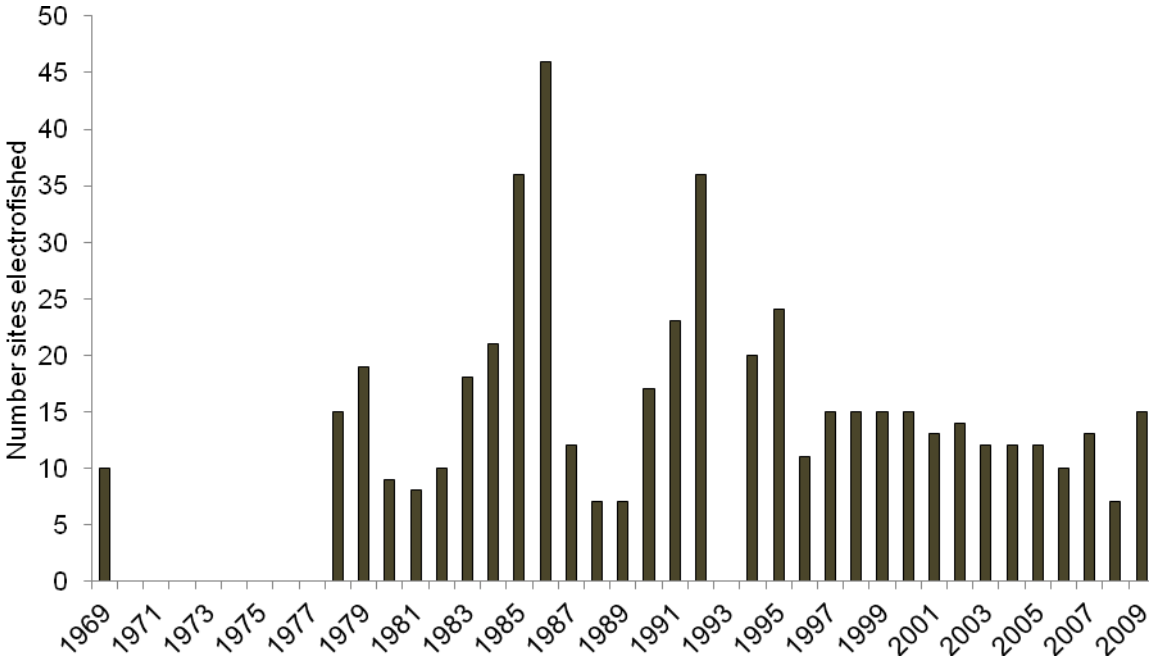

Figure 2: Number of sites electrofished each year in St. Mary's River watershed, 1969-2010 by DFO.

Limitations to the DFO data include: (1) species identification issues, and (2) comparison among different sampling methodologies.

Species identification issues: Of 845 counts of number of individuals per species (i.e., counts of numbers per species at a given site in a given year), there are identification issues with 325 counts (38.46%). That is, 9,817 records (8.5% of the total records) have ambiguity associated with identification. This uncertainty of identification fall into the following categories:

- *Alosa* unidentified (1,949 records in East Branch; 24 in North Branch; 90 in West Branch)
- Blacknose dace[2] (40 records in East Branch, 269 in West Branch)
- Brown trout - no other records of brown trout in St. Mary's River (2 records in East Branch; 2 in West Branch)
- Chub unidentified (90 records in East Branch; 1,029 in West Branch)
- Cyprinid unidentified (3 records in East Branch; 4 in West Branch)
- Dace unidentified (1,009 records in East Branch; 1,698 in West Branch)
- Shiner unidentified (931records in East Branch; 364 in North Branch; 3,770 in West Branch)
- Stickleback unidentified (28 records in East Branch; 17 in West Branch)

[2] Identification of fish as blacknose dace (*Rhinichthys atratulus*) is questionable as Gilhen and Hebda (2002) report this species not in Nova Scotia east of the Cobequid Mountains.

- Trout unidentified - most likely brook trout (93 records in East Branch; 47 in North Branch; 30 in West Branch)
- Unidentified (795 records in East Branch; 126 in North Branch; 800 in West Branch)

Of these records of unidentified fish, 95% involved unidentified dace, *Alosa*, shiner, chub, or general unidentified. That is, identification issues are primarily with the cyprinids. The approach for accounting for this uncertainty in calculating species diversity is described in *Data Analysis* below.

Sampling methodologies: There are three methods used by DFO for sampling fish communities using electrofishing: (1) Mark-recapture (of salmonids), (2) Multiple Pass, and (3) One Pass. In the first method, non-salmonids are captured incidentally but the focus is on salmonids. The three methods have differing levels of effort (electrofishing time) and timing (mark-recapture done over two days; multiple and one pass are one day only) and so may be expected to result in different estimates of number of species and individuals caught. The One Pass method has equivalent effort (mean 1,151.9 seconds; 95% CI ±257.8; n=75) to the Mark Recapture (mean 962.4 seconds; 95% CI ±147.5; n=321), and both are significantly greater shocking effort than the Multiple Pass (mean 323.9 seconds; 95% CI ±205.7; n=12)). Thus, the great majority of samples (396 of 408) showed similar electrofishing effort. However, as noted, the distribution of that effort is over two days (mark-recapture) versus a single day (one pass). A further limitation to using DFO and NSDFA electrofishing data for community analysis is that this sampling has concentrated on salmonid habitat of streams and so represents fish communities within this habitat. However, other communities present in non-salmonid habitat (e.g., cyprinid dominated) are not included in this sampling nor this analysis.

3.2 DATA ANALYSIS

Many of the systems sampled had multiple sites fished in various years (i.e., not the same site every year). For the sake of this analysis, these individual sites within a system were combined and the data treated as representing the system rather than a specific site. This ignores "within system" variation displayed by individual sites, but such an analysis would be confounded by time as sites changed among years and so any observed differences would not be unambiguously traceable to a spatial or temporal effect.

Species richness (S) is simply the number of species present in a sample and was calculated for each sampling occasion (site within the system and year) as the sum of individual species. Shannon-Weiner Diversity Index (H') was calculated for each site and year as:

$$H' = - \Sigma (p_i * \text{Log}(p_i))$$

where p_i = proportion of total fish captured comprised by species *i*

H' was calculated using the number of individuals per species in the sample, not by calculating population size or density and using those values.

Analysis of species diversity is complicated by the large number of individuals not identified to species but rather to higher taxonomic levels (e.g., shiner spp. chub spp. dace spp.). It is inappropriate to combine different levels of taxonomic resolution for diversity analysis. It would also be inappropriate to simply delete those records not identified to species as that would bias diversity low. To circumvent this difficulty H' was calculated based upon two scenarios. The first was that all unidentified species within a higher taxon in a sample were of the same, single species (i.e., richness of 1) and the second scenario was that unidentified fish were equally distributed among all species within that group that are known to occur in Nova Scotia. That is, unidentified dace were equally distributed as northern redbelly dace (*Chrosomus eos*) and pearl dace (*Semotilus margarita*), unidentified chub as lake chub (*Couesius plumbeus*) and creek chub (*Semotilus atromaculatus*), and unidentified shiner as golden shiner (*Notemigonus chrysoleucas*), common shiner (*Notropis cornutus*), and blacknose shiner (*Notropis heterolepis*). These two scenarios were designed to capture the two extremes for diversity calculations from where richness is 1 to where it, and evenness, are maximal for that fish grouping.

Of 259 diversity estimates involving these uncertain identifications, the mean difference between the two scenarios was 0.12 units (SD=0.14 units) or 12.2% (SD=13.5%). Median difference was 0.08 units (8.2%) with the scenario of equal distribution among 2-3 species producing greater H' values than assuming a single species. The true diversity value lies between the two extremes. For the sake of this analysis, diversity when unidentified species are included used equal distribution of unknown species among 2-3 species within the group, as it is more likely that when cyprinid species are present, it consists of more than a single species. This may bias those samples with unknown species slightly higher than others.

Evenness (J') is an estimate of how evenly the observed diversity is distributed among species. That is, are all species present in equal abundance (J' approaches 1.0) or is the community primarily dominated by a single species with others only present at very low abundance (J' approaching 0.0). J' is calculated as the observed H' as a proportion of maximum H' (H_{max}).

$$J' = H'/H_{max}$$

$$\text{where } H_{max} = \ln(S)$$

Comparisons among branches and among systems within branches are conducted using means ± 95% confidence intervals (CI), or medians for comparisons of central tendency. Evaluation of variation is by interquartile ranges (10^{th}, 25^{th}, 75^{th}, and 90^{th} percentiles) and by Coefficient of Variation (CV; %) defined as (SD/mean)*100.

4.0 RESULTS

4.1 SPECIES RICHNESS

Within the two datasets for the St. Mary's River are 20 positively identified species from 11 families (Table 2). The most species-rich family is the Cyprinidae (minnows) with 6 species. Seven fish species accounted for 80.6% of the total records; these were (in order): Atlantic

Table 2: Species list of fish captured during electrofishing operations in the St. Mary's River, 1969-2010.

Family	Species	Scientific Name	# records (DFO)	# records (NSDFA)
Petromyzontidae	Sea lamprey	*Petromyzon marinus*	911	0
Clupeidae	Alewife/ Gaspereau	*Alosa pseudoharengus*	85	0
	American shad	*Alosa sapidissima*	40	0
Salmonidae	Atlantic salmon	*Salmo salar*	51,830	176
	Brook trout	*Salvelinus fontinalis*	5,443	166
	Brown trout	*Salmo trutta*	4	0
Osmeridae	Rainbow smelt	*Osmerus mordax*	2	0
Cyprinidae	Common shiner	*Notropis cornutus*	2,696	25
	Golden shiner	*Notemigonus crysoleucas*	3	28
	Creek chub	*Semotilus atromaculatus*	261	4
	Lake chub	*Couesius plumbeus*	1,440	0
	Northern redbelly dace	*Chrosomus eos*	0	2
	Blacknose dace	*Rhinichthys atratulus*	4	0
Catastomidae	White sucker	*Catastomus commersoni*	6,221	96
Ictaluridae	Brown bullhead	*Ameiurus nebulosus*	0	1
Anguillidae	American eel	*Anguilla rostrata*	30,860	52
Cyprinodontidae	Banded killifish	*Fundulus diaphanus*	117	7
Gasterostidae	Ninespine stickleback	*Pungitius pungitius*	1	1
	Threespine stickleback	*Gasterosteus aculeatus*	54	0
Percidae	Yellow perch	*Perca fluviatalis*	1	3
Unidentified	*Alosa* unidentified		2,063	0
	Chub unidentified		1,119	71
	Cyprinid unidentified		7	0
	Dace unidentified		3,016	19
	Shiner unidentified		5,065	17
	Stickleback unidentified		45	0
	Trout unidentified		170	0
	Unidentified		1,721	0

salmon (25.7%), American eel (19.2%), white sucker (12.5%), brook trout (12.5%), common shiner (5.6%), and sea lamprey (5.1%) (Figure 3). Atlantic salmon and American eel, alone, represented 45.5% of all records. Among branches, median richness per sample ranged between 3.5 and 4.0 species, with a maximum number per sample being 9 species (Table 3); this highest value was captured on three occasions, once at McLeod Lake Brook (2005) and twice in West River mainstem at Caledonia (2006 and 2008). The numerically dominant species were the same

for each branch (Figure 4) – Atlantic salmon, American eel, white sucker and brook trout. Ninety percent of the 850 samples from the East and West branches contained 6 or fewer species, and the central 50 percentile of the distribution ranged from 2 to 5 species.

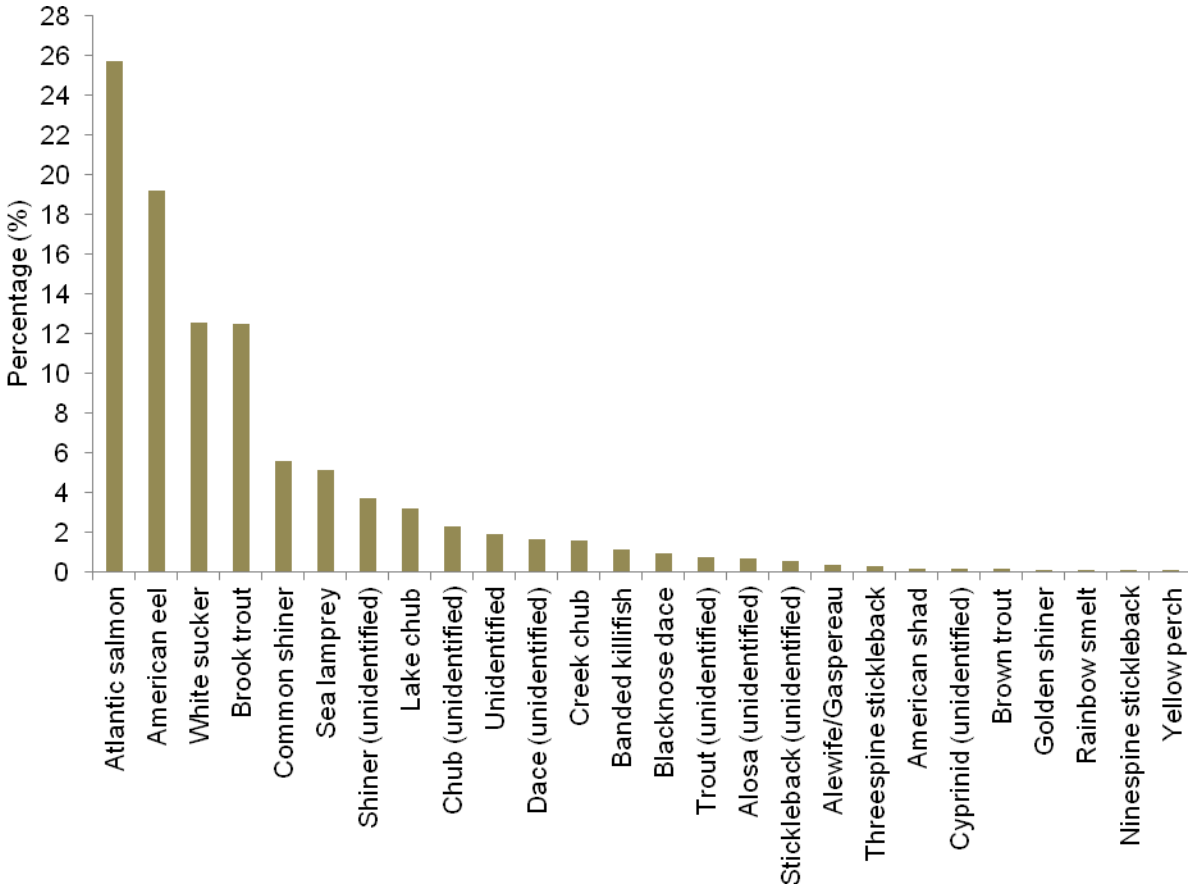

Figure 3: Frequency distribution of occurrence of individual species for the St. Mary's River from total of 3,192 species occurrences, where a species occurrence is the presence of species *i* at location *k* at time *t*.

Examining the individual systems within a branch, all systems have similar fish species richness (Figure 5). Median richness, based on systems with sample sizes >5, ranged between 2 and 5 species. Of 21 systems with $n \geq 5$, 15 had median richness of 3 or 4 species. Using Coefficient of Variation (CV) as a measure of within-branch variation, the CV of the East Branch is 36.1%, the West Branch 37.5%, and North Branch 17.9%. This suggests that species richness and variation are similar among branches. That is, there is little variation in richness among systems within a branch or between branches.

Table 3: Summary statistics of fish community species richness and diversity by river branch in the St. Mary's River watershed, 1969-2010.

	Richness (S)			Diversity (H')		
	East Branch	North Branch	West Branch	East Branch	North Branch	West Branch
Mean (95 % C)	3.51 (0.17)	3.1 (0.99)	4.03 (0.16)	0.83 (0.04)	0.81 (0.28)	1.01 (0.04)
SD	1.67	1.59	1.75	0.36	0.43	0.43
N	379	10	471	319	9	429
Range	1- 7	1-6	0 -9	0 – 1.82	0.09 – 1.60	0.08 – 2.17
Median	4	3.5	4	0.79	0.69	1.03
10th percentile	1	1	2	0.36	0.27	0.42
25th percentile	2	2	3	0.58	0.57	0.68
75th percentile	5	4	5	1.06	1.02	1.29
90th percentile	6	4.2	6	1.35	1.57	1.61

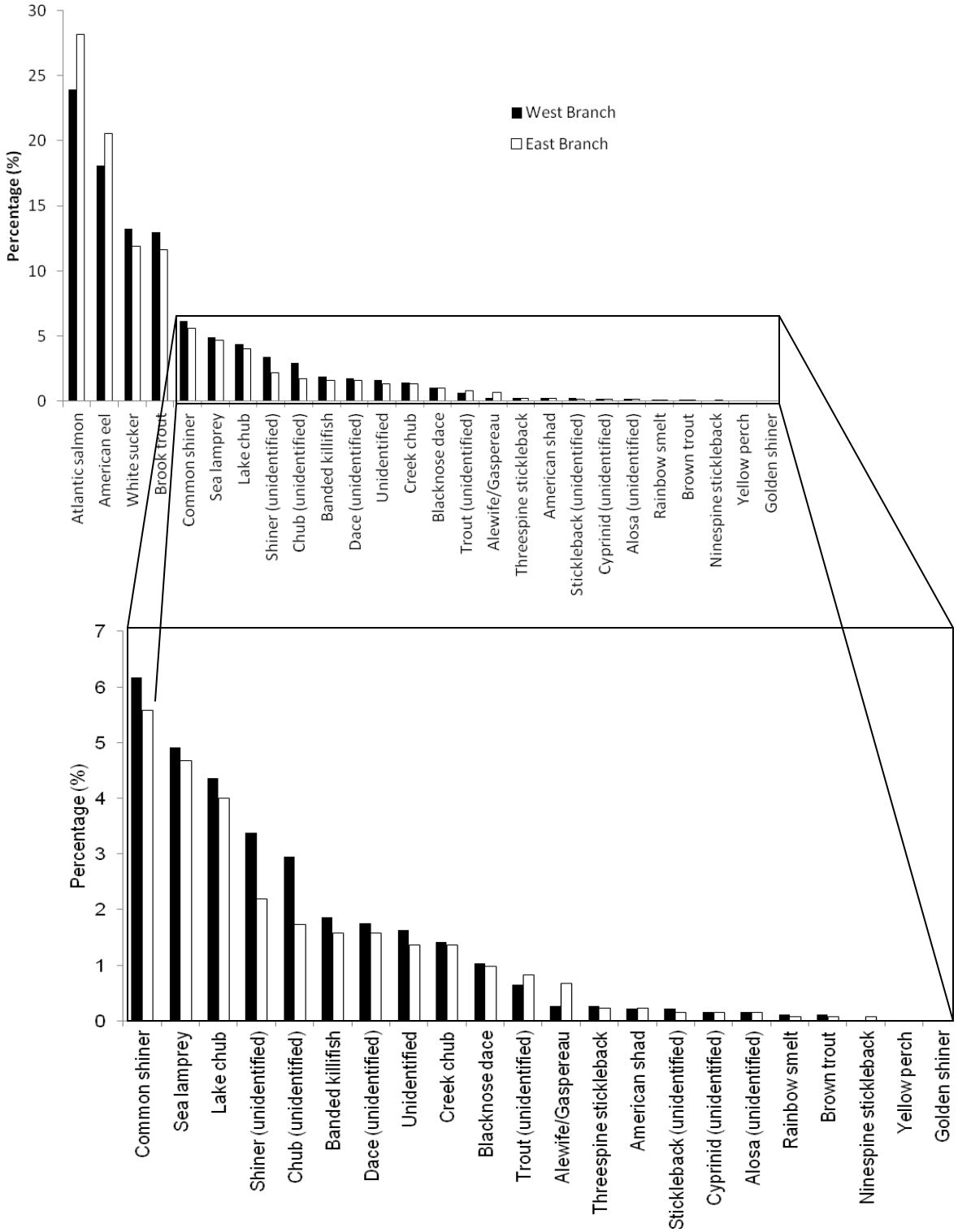

Figure 4: Frequency distribution of occurrence of individual species for each of the East and West Branches from total of 3,192 species occurrences, where a species occurrence is the presence of species *i* at location *k* at time *t*. Lower panel is magnified view of lower one-third of upper panel for clarity of small values.

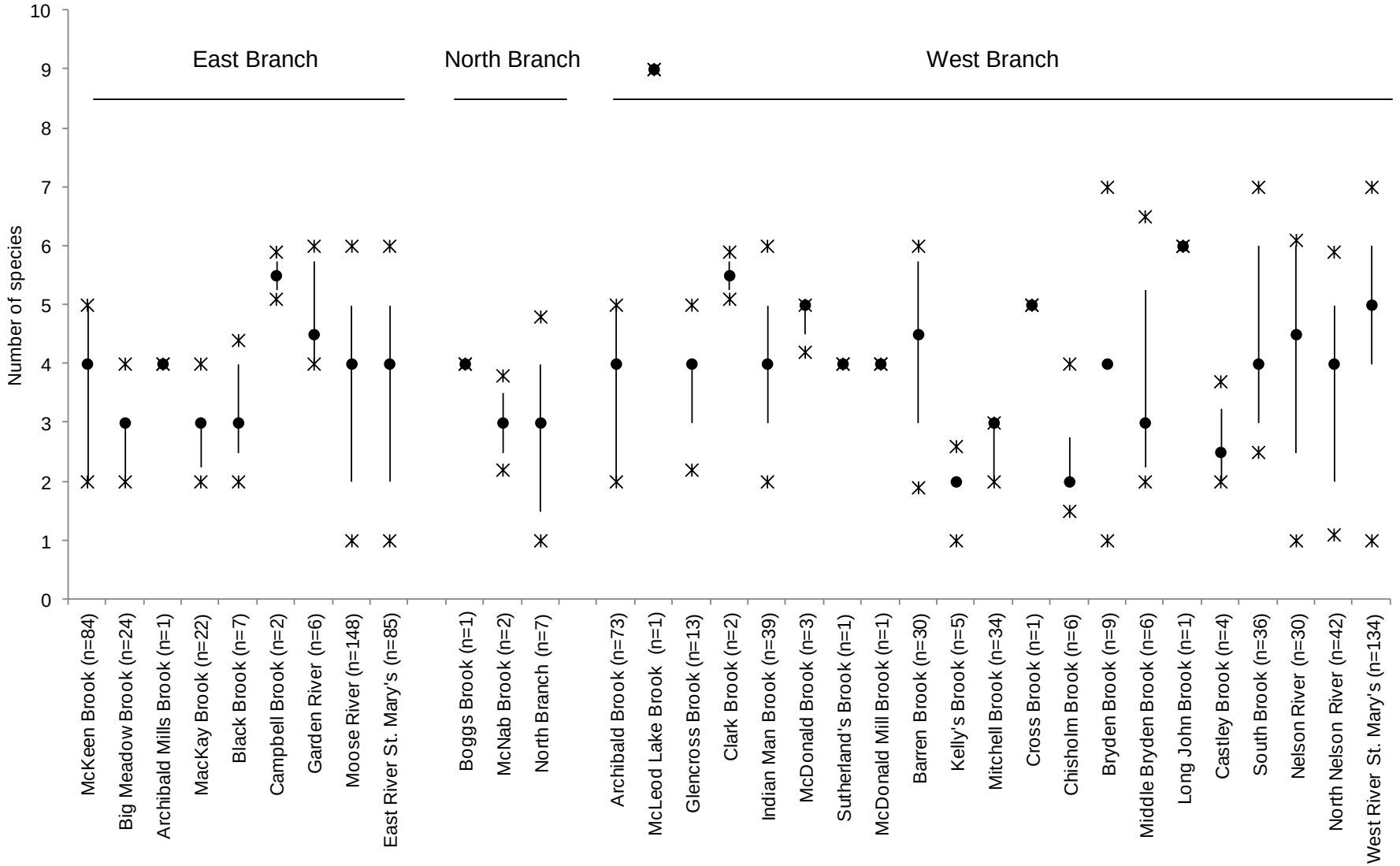

Figure 5: Median richness (closed circles) by system in the St. Mary's River watershed. Error bars represent range of 25th -75th percentile, asterisks the 10th and 90th percentiles. Sample sizes are provided for each system on the x-axis.

4.2 SPECIES DIVERSITY

The East Branch had a lower median Shannon-Weiner diversity value (0.79 units) than the West Branch (1.03 units) ($p<<0.001$; chi square analysis of difference of medians; Zar, 1999) (Table 3, Figure 6). The distribution of diversity indices within a branch is quite uniform and continuous for each branch, with the interquartile (10^{th} to 90^{th} percentile) range of all estimates combined being 0.35 to 1.35 units (East Branch) and 0.42 to 1.60 units (West Branch) (Figure 6).

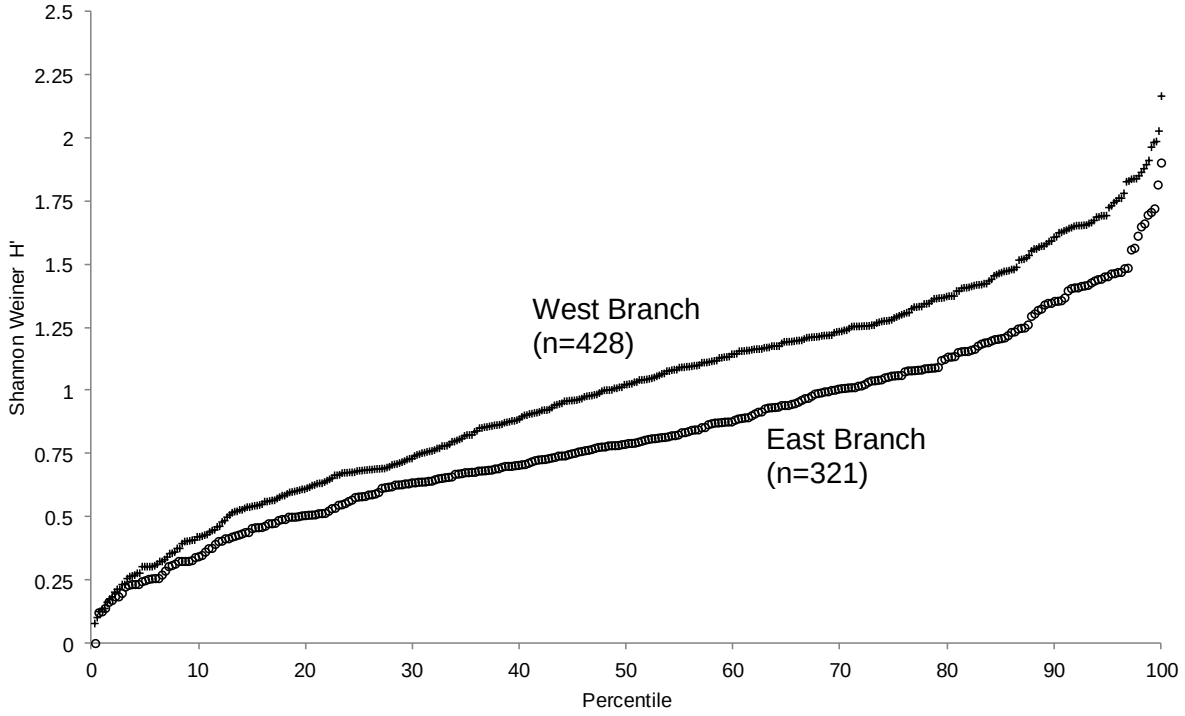

Figure 6: Cumulative frequency distribution of Shannon Weiner diversity index values for the East and West Branches St. Mary's River. Each data point represents one site X year estimate.

Individual system median diversity, based on systems with sample sizes >5, ranged between 0.64 and 1.42 units (Figure 7). The central 50% of the distribution (i.e., from 25^{th} to 75^{th} percentile) was 0.48 units (East Branch) and 0.44 units (West Branch), while the central 80% of the distribution (i.e., from 10^{th} to 90^{th} percentile) was 0.99 units (East Branch) and 1.30 units (West Branch). Using Coefficient of Variation as another measure of within-branch variation, the CV of the East Branch is 43.3%, and the West Branch 42.6%. This is suggestive that the variation of diversity estimates within a branch is similar in the East and West Branches. The largest values of H' (H'>1.25) in Long John (=Black), Campbell's, Cross, and McLeod Lake Brooks are based on sample sizes of 1 or 2 and so are less reliable than those systems with ≥5 samples. Of those with n≥5, the brooks showing the greatest median diversity (H'>1.0) are South Brook, Nelson River and West Branch St. Mary's.

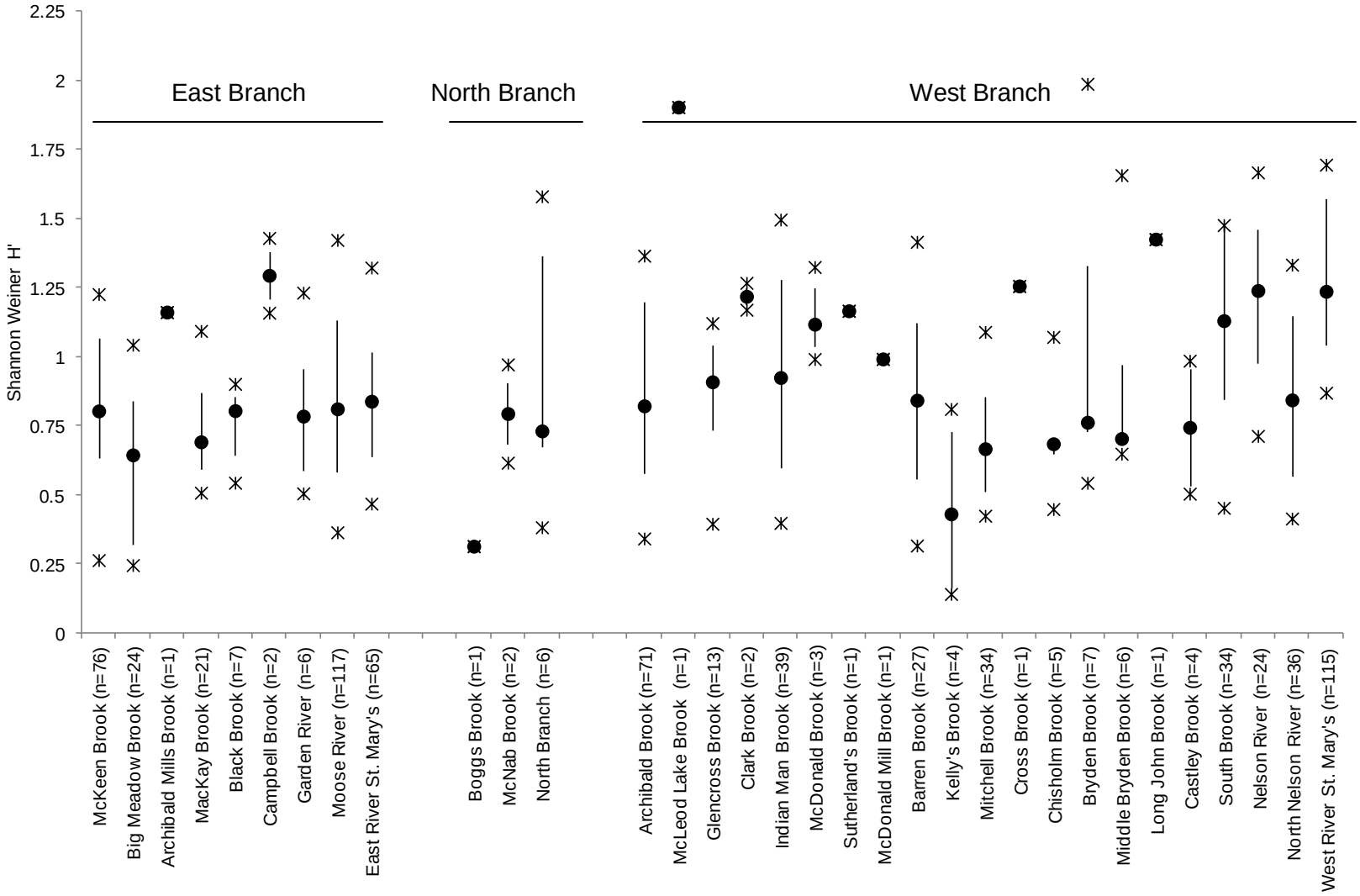

Figure 7: Median Shannon-Wiener Diversity index (H'; closed circles) by system in the St. Mary's River watershed. Error bars represent range of 25th-75th percentile, asterisks the 10th and 90th percentiles. Sample sizes are provided for each system on the x-axis.

To examine changes in H' over time, linear regressions were conducted of mean diversity against years for each system in which there were ≥20 estimates of diversity. Regressions for five systems on the East Branch and eight systems on the West Branch showed no significant regressions (Table 4), suggesting no obvious indication of directed change (increase or decrease) in diversity over time.

Table 4: Results of regression analysis of mean Shannon-Weiner diversity index over years for systems within the St. Mary's River.

System	Regression Equation	Number of years	r^2	p-value
EAST BRANCH				
McKeen's Brook	H' = -0.001 * Year + 2.877	26	-0.039	0.798
Big Meadow Brook	H' = -0.175 * Year + 35.430	6	-0.089	0.485
MacKay Brook	H' = -0.018 * Year + 37.488	7	0.025	0.331
Moose River	H' = -0.005 * Year + 10.690	26	-0.009	0.384
East River St. Mary's	H' = -0.005 * Year + 11.724	21	-0.012	0.394
WEST BRANCH				
Archibald's Brook	H' = -0.008 * Year + 17.798	21	0.044	0.182
Indian Man Brook	H' = 0.004 * Year - 8.300	21	-0.039	0.620
Barren Brook	H' = -0.005 * Year + 10.124	14	-0.07	0.674
Mitchell Brook	H' = -0.011 * Year + 23.123	21	0.071	0.128
South Brook	H' = -0.005 * Year + 10.495	19	-0.033	0.526
Nelson River	H' = -0.014 * Year + 23.123	17	0.06	0.174
North Nelson River	H' = 0.011 * Year - 20.870	15	-0.037	0.506
West River St. Mary's	H' = 0.008 * Year - 15.015	31	0.066	0.087

Thus, diversity is shown to be, on average, less in the East Branch than West, show similar variation among systems within these two branches, and not indicate directional change (trend) over time.

4.3 EVENNESS

Evenness (J') is statistically lower in the East Branch (mean 0.608; SD=0.192; n=317; 95% CI=0.021) than the West Branch (mean 0.685; SD=0.179; n=416; 95% CI=0.017), suggesting a more even contribution by community members in the West than East Branch. However, this is a statistical difference, it is unlikely that this small difference in J' (0.08 units or 8%) between branches is ecologically meaningful. The variation among systems within a branch is low (East

Branch CV=9.5%; West Branch CV 11.5%). The North Branch had a mean evenness intermediate to the other two branches but of greater variance (mean 0.671; SD=0.308; n=9; 95% CI=0.201). This variation was driven by a very low evenness value (0.22) in Bogg's Brook (n=1).

5.0 DISCUSSION

The richness of the St. Mary's River is typical of Nova Scotia, which is depauperate relative to more continental systems (e.g., New Brunswick 49 species; Curry and Yamazaki, 2012), but more species rich than truly insular systems (e.g., 4 species in Newfoundland; Mitchell et al., 2005 or 7 species on Prince Edward Island[3]). There are only 30 completely freshwater or diadramous native species using freshwater in Nova Scotia (Davis and Brown, 1996) of which 66% are represented in the St. Mary's. Numerically dominant species (Atlantic salmon, American eel, white sucker, brook trout) are consistent with other studies in Atlantic Canada (Mitchell et al., 2004; 2005) There is little spatial variation within or among branches, with typical richness being 3-4 species.

In terms of Shannon-Weiner diversity, the West Branch is of slightly greater diversity than the East Branch, though variation among tributaries within a branch is similar between the East and West Branches. The larger values of H' are generally associated with the larger systems and this follows from the River Continuum Concept (Vannote et al., 1980); a central concept in stream ecology. The River Continuum Concept predicts an increase in fish diversity with stream size due to an increase in available space but also to an increasing diversity of habitats which may be exploited by more species. This likely explains what is seen here. There is no evidence of areas within the St. Mary's River of consistently lower (or greater) diversity than others. With the exception of the noted increase in stream size, suggesting none of the sampled areas are significantly impacted or modified. However, neither are any areas exceptional for promoting species diversity over others. Further, there are no obvious trends over time indicating either increasing or decreasing diversity. Rather, diversity appears to be stable over the long-term.

A more sophisticated diversity analysis (e.g., cluster analysis or Jaccard Index) were considered but not conducted here. These analyses were thought to be not effective with these data as the communities are clearly dominated by few widespread species (salmon, eel, sucker, trout) and the number of members in the community is small (<9). Thus the individual communities are likely not sufficiently distinct to reward analysis. Additionally, the variation in sampling over time (number of sites/system, number of years, one pass versus mark-recapture) confound analysis as sampling effort is not similar among sites (i.e. mark-recapture involves two passes on separate days versus one pass being a single pass on one day). Those with more sites/system conducted in a given year, or a mark-recapture sampling regime rather than one-pass, are likely to show more species than those with less effort. These limitations to the data preclude reliable interpretation of a sophisticated analysis.

[3] This estimate is from PEI Department of Agriculture and Forestry (http://www.gov.pe.ca/agriculture/index.php3?number=1006016&lang=E), but is likely an underestimate as it only includes commercial and recreational species.

This observed relatively high values of evenness are likely accounted for by the ubiquitous and common species of salmon, eel, sucker and trout. Not only are they widespread throughout the watershed, but also a common member of the fish community. The other 16 identified species are not sufficiently commonly encountered, or abundant when encountered, to influence the evenness.

6.0 CONCLUSIONS

The richness of the St. Mary's River is typical of Nova Scotia, which is depauperate relative to more continental systems, but more species rich than truly insular systems. Numerically dominant species (Atlantic salmon, American eel, white sucker, brook trout) are consistent with other studies in Atlantic Canada. West Branch Shannon-Weiner diversity is of slightly greater diversity than the East Branch, though variation among tributaries within a branch is similar between the East and West Branches. There is no evidence of areas within the St. Mary's River of consistently lower (or greater) diversity than others. Further, there are no obvious trends over time indicating either increasing or decreasing diversity. Rather, diversity appears to be stable over the long-term. These communities are clearly dominated by few widespread species (salmon, eel, sucker, trout) and the number of members in the community is small. The observed relatively high values of evenness are likely accounted for by the ubiquitous and common species of salmon, eel, sucker and trout.

7.0 LITERATURE CITED

Curry, R.A., and G.P. Yamazaki. 2012. Inland fishes of New Brunswick. Canadian Rivers Institute. Available at: http://www.unb.ca/fredericton/science/biology/Fish_key/fish%20welcome.htm. Accessed January 30, 2012.

Davis, D.S. and S. Browne. 1996. The natural history of Nova Scotia. Volume One: topics and habitats. Nimbus Publishing and Province of Nova Scotia. 518pp

Gilhen, J., and A. Hebda. 2002. Distribution of Blacknose Dace, *Rhinichthys atratulus*, in Nova Scotia. Canadian Field-Naturalist [Can. Field-Nat.]. 116 (4): 536-546.

Mitchell, S.C. 2009. A Review and Analysis of the Hydrology of the St. Mary's River, Guysborough County, Nova Scotia. St. Mary's River Association Technical Report #001.

Mitchell, S.C. 2011. Water Quality of the St. Mary's River Watershed: A detailed Analysis. St. Mary's River Association Technical Report #011.

Mitchell, S., A. Fraser, P. Hardie, and R.A. Cunjak. 2004. Electrofishing data summaries for Catamaran Brook, New Brunswick, 1990-2002. Canadian Data Report of Fisheries and Aquatic Sciences. 1130.

Mitchell, S.C., D.A. Scruton, R.A. Cunjak, and R.J. Gibson. 2005 Atlantic salmon and brook trout population and habitat characteristics of Northeast Brook, Trepassey, Newfoundland and Labrador, 1984-96. Canadian Technical Report of Fisheries and Aquatic Sciences. 2596.

Vannote, R.L., G.W. Minshall, K.W. Cummins, J.R. Sedell, and E. Gushing. 1980. The river continuum concept. Canadian Journal of Fisheries and Aquatic Sciences. 37: 130-137.

Zar, J.H. 1999. Biostatistical analysis. Fourth edition. Prentice Hall. Upper Saddle River, NJ.