St. Mary's River Watershed Synoptic Survey

Robert W. Paul, Ph.D.
Department of Biology
St. Mary's College of Maryland
St. Mary's City, MD 20686
In Partnership with
St. Mary's River Watershed Association, Inc.
PO Box 94, St. Mary's City, MD 20686

September 30, 2008

Financial assistance provided by the Coastal Zone Management Act of 1972, as amended, administered by the Office of Ocean and Coastal Resource Management, National Oceanic and Atmospheric Administration (NOAA). A report of the Maryland Coastal Zone Management Program, Department of Natural Resources pursuant to NOAA Award No. NA06NOS4190237. Additional financial support provided by the Chesapeake Bay Trust Stewardship Grant (#9181).

Table of Contents

List of Figures

List of Tables

Summary

Both the tidal and non-tidal portions of the St. Mary's River are contained entirely within St. Mary's County, and the watershed has an area of approximately 47,000 acres. Ten subwatersheds and 174 miles (280 km) of streams contribute freshwater to the tidal St. Mary's River. The tidal St. Mary's River is approximately 12 km in length and is fed by numerous tidal creeks, but these contribute little freshwater flow to the river. As the river flows into the tidal Potomac River, the St. Mary's is 12 meters deep.

A synoptic survey was conducted by St. Mary's College of Maryland personnel beginning on April 1 and concluding on September 30, 2008, with the assistance of the Watershed Assessment Division of the Maryland Department of Natural Resources (DNR). The assessment included water quality monitoring and nutrient analyses at 15 non-tidal stations and a single station at the mid-point of the tidal reach. Non-tidal sampling was conducted once on July 10 and 11, 2008, and tidal sampling took place every two weeks at the St. Mary's College of Maryland dock beginning on April 15th. Water quality readings were taken with a YSI 6600 sonde that recorded water temperature, pH, conductivity, salinity, chlorophyll *a*, and dissolved oxygen (mg/L and % saturation) at 0.5, 1.0, 2.0, and 3.0 meters depth. Secchi disk depths were also taken when sonde measurements were made. Biological sampling also occurred in April for macroinvertebrates and in July for fish. All procedures followed Maryland Biological Stream Survey (MBSS) protocols.

The results of the synoptic survey support the idea that the tidal creeks of the St. Mary's River have poorer water quality that the open main stem of the river. Storm events seem to be the dominant perturbation force in the river, bring nutrients and sediments into the tidal main stem, from as far away as the Lexington Park development district, the primary area of urban development in St. Mary's County. Yet, the impacts of sediment generation through erosion seem to be more localized near their points of production. The main impact is habitat degradation affecting the biological resources of the streams. In the tidal river, nutrients and sediments fuel algal production, which diminishes light passage through the water column, and lowers dissolved oxygen content of the water as the algae die, sink, and decompose. Yet, water quality tends to be reasonably good in much of the watershed, its streams and the main stem of the river. Nutrient concentrations are below levels of concern under normal flow regimes.

Introduction

Both the tidal and non-tidal portions of the St. Mary's River are contained entirely within St. Mary's County, and the watershed has an area of approximately 47,000 acres (Figure 1). Six subwatersheds contribute freshwater to the tidal St. Mary's River and drain the majority (25,000 acres) of the upper watershed's land area (KCI, 1998). Four other, small subwatersheds are located in the southeastern portion of the county and drain directly into the tidal river. The main stem of the non-tidal St. Mary's River has three important subwatersheds: The Upper St. Mary's River, Eastern Branch, and Western Branch. The Western Branch is impounded to create St. Mary's Lake with a surface area of approximately 250 acres (Boward et al., 1998). Many of the 10 total subwatersheds have a relatively large proportion of land that is classified as unsuitable for development (23-44%), and some of the most sensitive areas of the watershed are likely to see major development pressures in the near future (KCI, 1998; Stranko and Rodney, 2001).

The tidal St. Mary's River is approximately 12 km in length and is fed by numerous tidal creeks, but these contribute little freshwater flow to the river. The bottom of the river is relatively flat and is 12 m deep at the mouth. The lower, tidal Potomac River is the source of salinity in the river and flood tides create a salinity wedge that is strongly mixed throughout the water column. Salinity is associated with season and the highest annual salinities occur in the late summer- early fall while the lowest salinities occur in the spring.

The St. Mary's River and its watershed have been intensively studied for the past 10 years (Paul, 2006; Paul and Tanner, 2001, 2005). The historical results of these studies have been compiled and discussed in the Watershed Characterization portion of a Watershed Restoration Action Strategy (WRAS) study supported by Maryland DNR. These studies which were begun in June of 1999 are focused on tidal and non-tidal water quality monitoring and biological resource assessment, and make up the on-going St. Mary's River Project (SMRP). This project is collaboration between St. Mary's College of Maryland faculty and students and state and federal agencies with a goal of long-term monitoring, research, and education.

This synoptic survey of current chemical and biological conditions was also performed as a part of this St. Mary's River WRAS. The study period, April 1 – September 30, 2008, covered DNR's Maryland Biological Stream Survey (MBSS) protocols for macroinvertebrates (Spring Index Period) and for fish (Summer Index Period), and this allowed for biological resource assessment to be included in the synoptic survey. Water quality measures were also a central part of this synoptic survey and because the St. Mary's River has both tidal and non-tidal segments, water quality was assessed by slightly different methods using slightly different parameters for each type of water.

Because non-tidal data collection needed to be consistent with other studies at local, regional and state levels, we employed the protocols in the Maryland Biological Stream Survey (MBSS) Sampling Manual (Kazyak, 1997). These procedures were patterned after

USEPA protocols (Plafkin et al., 1989), and the methods when properly applied, accurately assess physical and chemical characteristics and document biological resources of streams (Roth et al., 1997).

Methods

Water Quality Monitoring

In this synoptic survey, tidal and non-tidal waters were sampled for physical and water quality parameters including an extensive analysis of nutrients.   A single tidal station was established at the St. Mary’s College of Maryland dock because of its easy access, because it is mid way between the head of tide and the mouth of the tidal river, and because historical data is available for this station (Figure 1). This station was used for water quality collections made every 2 weeks beginning in April of 2008 and concluding in September. The non-tidal stations used were the 15 SMRP non-tidal stations, and these were selected because of the long-standing (1999- present) data record at 14 of the 15 stations (Figure 1, Table 1). These stations were sampled once on July 10 and 11, 2008.

Table 1. St. Mary’s River Watershed sampling stations.

Location	Station	Station ID	Latitude	Longitude
NON-TIDAL STATIONS			(DD MM.MMMM)	(DD MM.MMMM)
	SMNT01	Locust Grove Cove	N38°09.9576'	W76°30.0867'
	SMNT02	Warehouse Run	N38°13.2480'	W76°29.3880'
	SMNT03	Below St. Mary's Lake	N38°15.1338'	W76°31.9680'
	SMNT04	In St. Mary's River Lake	N38°15.1512'	W76°32.4858'
	SMNT05	Landfill Tributary	N38°16.8810'	W76°31.0362'
	SMNT06	Hickory Hills	N38°16.7538'	W76°30.8016'
	SMNT07	Norris Road	N38°16.3614'	W76°30.7218'
	SMNT08	Jarboesville Run	N38°15.1650'	W76°30.4170'
	SMNT09	USGS Gaging Station	N38°14.5080'	W76°30.2184'
	SMNT09.5	Johns Creek	N38°14.2020'	W76°30.0540'
	SMNT10	Hilton Run	N38°13.8456'	W76°27.9060'
	SMNT11	Pembrook Run	N38°13.4604'	W76°27.3252'
	SMNT12	Eastern Branch	N38°13.7658'	W76°25.7322'
	SMNT13	Fisherman Creek	N38°12.1038'	W76°25.1562'
	SMNT14	Church Creek	N38°09.7512'	W76°30.0222'
TIDAL STATION	T01	St. Mary’s College	N38°11.3220'	W76°26.3940'

Non-tidal stations were selected to characterize four general watershed regions. As the upper St. Mary’s River and middle branches drain a vast majority of the watershed, providing the largest volume of freshwater entering the tidal St. Mary’s River, the majority sampling sites (11 of 15) were concentrated here. For the most part, either USEPA (Plafkin et al., 1989) or MBSS (Kazyak, 1997) protocols were used to originally select nontidal sites. Selection criteria were applied to all potential non-tidal stream sites: 1) stream order (Horton, 1945),

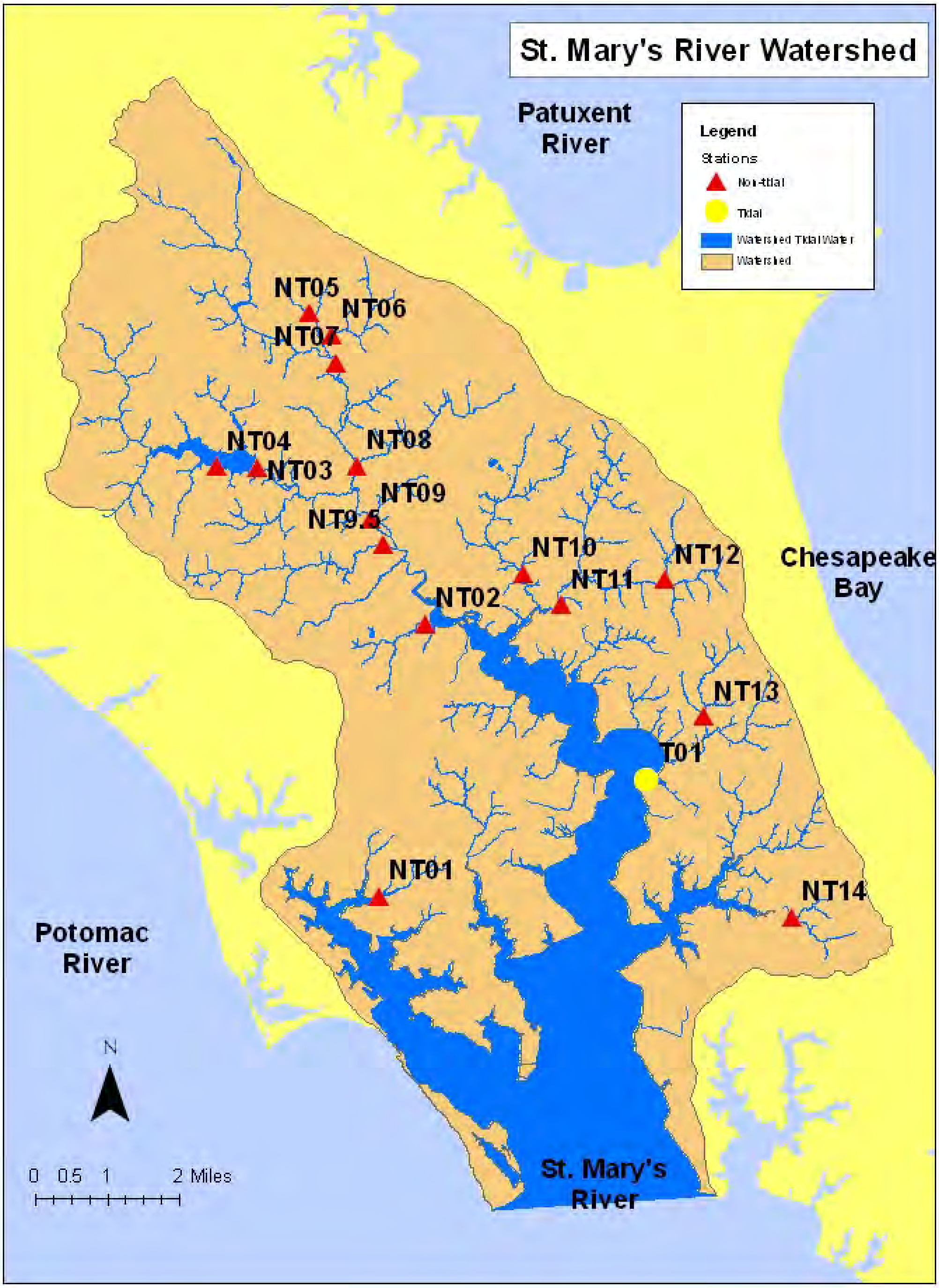

Figure 1. St. Mary's River Watershed (St. Mary's County, Maryland) showing tidal station T01 at the St. Mary's College and all non-tidal (SMNT) sampling stations.

2) relative position in the watershed, 3) whether the sampling site was representative of the stream, 4) site position relative to upstream sampling locations, 5) site position relative to tidal sampling locations, 6) accessibility, and 7) special considerations (such as distinctive features or attributes). Based on these analyses it was determined in 1999 that 14 stations could adequately characterize the freshwater portion of the watershed. The 15th non-tidal station, NT9.5- Johns Creek, was added in 2001.

Yellow Springs Instrument (YSI, Yellow Springs, OH) multi-parameter water quality sondes (Model 6600) were used to measure water temperature, salinity, dissolved oxygen (DO), pH, turbidity, and *in situ* chlorophyll fluorescence at the tidal station (Table 2) at 0.5, 1.0, 2.0 and 3.0 m. Sondes were calibrated in the laboratory using manufacture's specifications prior to each sampling trip. Nutrient samples were taken from May through August at the surface. All sampling equipment used in the filtering process was rinsed three times with sample water. After filtering was complete all filter pads were stored in aluminum foil envelopes on ice in sealed polyethylene bags. All tidal samples were returned on ice to the laboratory on the same day that they were collected. Nutrient samples were immediately frozen in a secured freezer before being transported to the Analytical Chemistry Laboratory at Chesapeake Biological Laboratory– CBL (University of Maryland) in Solomons.

<u>Total Suspended Solids and Volatile Suspended Solids (TSS/VSS)</u>
Two pre-fired, pre-weighed Whatman 47mm GF/F 0.7 µm filters (provided by Chesapeake Biological Laboratory, CBL) were placed in a dual filtering manifold. The water sample was agitated and a 100ml volumetric pipette used to transfer 300 ml of sample water to each filter. In the case of an extremely turbid sample volume was reduced. All volumes filtered were recorded on the filter envelope and the datasheet. Vacuum was provided using hand held pumps at a vacuum of no more than 20 cm Hg. After the sample water had passed through the filter, the funnel and filter were rinsed with distilled water. Each filter was removed, folded in half, and placed in an aluminum foil envelope pre-labeled with the CBL filter number.

<u>Particulate Carbon and Particulate Nitrogen (PC/PN)</u>
After agitating the sample a 100 ml volume was filtered through a pre-combusted Whatman 25mm GF/F 0.7 µm filter. The filter was then folded in half and placed in an aluminum foil envelope. After again agitating the sample, a 100 ml volume was filtered through another 25mm GF/F filter. This filter was folded in half and placed in the foil envelope with the first filter making sure they did not touch one another.

<u>Particulate Phosphorus and Particulate Inorganic Phosphorus (PP/PIP)</u>
A dual manifold filtration system was used in the TSS/VSS analysis and was loaded with Whatman 47mm GF/F 0.7 µm filters. The sample was agitated and a 100 ml volumetric pipette used to transfer 300 ml to each filter. If the volume was reduced for the TSS/VSS analysis because of high turbidity, then the same volume was used for this analysis. After the sample was rinsed with distilled water, the filters were folded in half and placed in an aluminum foil envelope so that they did not touch.

Chlorophyll *a* (Chla)
A single 47mm filtering manifold was set up using a Whatman GF/F 0.7 μm filter, after disposing of the filtrate from previous filtering. The sample was agitated and a 100 ml volumetric pipette used to transfer 200 ml of sample to the filter apparatus. Vacuum was applied using a hand pump to a vacuum of no more than 20 mg Hg. The filter was then folded in half and placed in an aluminum foil envelope.

The filtrate from the chlorophyll analysis was collected for additional nutrient analyses. All vials and bottles were rinsed three times with the filtrate. Four 4.0 ml polystyrene sample cups with conical bottoms (Evergreen Scientific, 127-0066-010) were filled for: nitrite + nitrate (NO_2^-+NO_3^-), ammonium (NH_4^+), and phosphorus (orthophosphate). One glass tube was filled with 10 ml for TDN/TDP analysis. In addition, a 60 ml polystyrene bottle was filled as a TDN/TDP duplicate. One 30 ml Teflon bottle was filled for carbon (DOC) analysis. All these samples were then stored on ice in sealed polyethylene bags. Secchi disk depth was measured with a standard 20 cm disk.

Samples were returned on ice to the laboratory on the same day that they were collected. Nutrient samples were immediately frozen in a secured freezer before being transported to CBL for analysis. Total phosphorus, nitrogen, and carbon were calculated by summing dissolved and particulate fractions. All analytical data or sample tracking data was entered on computer storage devices. Tidal results were processed by CBL for May samples, but a heavy work load prevented at CBL from reporting June-August results, and these data are missing from this report.

Table 2. Parameters, methods and analytical laboratories performing analyses for water quality samples taken at all stations. A YSI 6600 sonde was used at the tidal station and a YSI 600XLM sonde used at non-tidal stations for ISM - *in situ* measurement. D indicates a discrete grab sample. * indicates that the parameter was sampled only at tidal stations or St. Mary's Lake (NT04).

Samples	Parameter Title	CIMS code	Units	Method	EPA Method
D	Chlorophyll a *	CHLA	UG/L	L03	-
D	Dissolved organic carbon	DOC	MG/L	L02	415.1
D	Ammonia	NH4F	MG/L	L01	350.1
D	Nitrite	NO2F	MG/L	L01	353.2
D	Nitrite-Nitrate	NO23F	MG/L	L01	353.2
D	Particulate carbon	PC	MG/L	L01	440.0
D	Particulate inorganic phosphorus	PIP	MG/L	L01	-
D	Particulate nitrogen	PN	MG/L	L01	440.0
D	Orthophosphate	PO4F	MG/L	L01	365.1, 365.5
D	Particulate phosphorus	PP	MG/L	L01	-
D	Total dissolved nitrogen	TDN	MG/L	L01	-
D	Total dissolved phosphorus	TDP	MG/L	L01	-
D	Total suspended solids	TSS	MG/L	L01	160.2
D	Volatile suspended solids	VSS	MG/L	L01	160.4
ISM	Water temperature	WTEMP	DEG C	F01	170.1
ISM	Specific Conductance	COND	UMHOS/CM	F01	-
ISM	Salinity	SALINITY	PPT	F01	-
ISM	Dissolved Oxygen-Saturation	DO_SAT	PCT	F01	-
ISM	Dissolved Oxygen-Concentration	DO	MG/L	F01	360.1
ISM	pH	PH	SU	F01	150.1
ISM	Chlorophyll a *	CHLA	UG/L	F01	-
ISM	Secchi Disk Depth *	SECCHI	M	F01	-

All non-tidal stations were accessed by vehicle on either July 10 or July 11. Water samples were collected and analyzed using methods similar to those used at the tidal station (Table 2). Water sampling was done by discrete grab sampling (a surface sample taken with a bucket) or by instrument. A Yellow Springs Instrument (YSI, Yellow Springs, OH) multi-parameter water quality sonde (Model 600XLM) was used to measure water temperature, conductivity, dissolved oxygen (DO), and pH (Table 2). The YSI sonde was calibrated in the laboratory using manufacture's specifications prior to each non-tidal sampling trip.

Grab sample water was used for all analyses. All sampling equipment used in the filtering process was rinsed three times with sample water. After filtering was complete all filter pads were stored in aluminum foil envelopes on ice in sealed polyethylene bags. The same procedures listed above for tidal sampling were employed at non-tidal stations.

All non-tidal samples were returned on ice to the laboratory on the same day that they were collected. Nutrient samples were immediately frozen in a secured freezer before being transported to CBL for analysis on July 12, 2008. The Nutrient Analytical Services Laboratory of the Chesapeake Biological Laboratory maintains published analytical procedures, SOPs, and QA/QC protocols and these are also detailed on their web site (http://www.cbl.umces.edu/nasl/).

Biological Sampling Methods

Chronologically, during this study period, macroinvertebrates were collected first because collections needed to be completed by the end of the Spring Index Period, May 1st (Kazyak, 1997). Because Stream Waders volunteers were sampling in the St. Mary's River watershed at this time, we coordinated our sampling efforts, and sampled the synoptic survey sites at the same time on April 15, 2008. MBSS protocols (Kazyak, 1997) were followed for kick net sampling and 7 sampling sites that had been used in previous SMRP studies (NT02, NT05, NT06, NT09, NT9.5, NT10, and NT11) were collected in 2008. Three new sites were collected as well. The first was located on Indian Bridge Road just below the bridge across the St. Mary's River, the second was located on the St. Mary's River at the kayak launch park in Great Mills, and the third was on Craney Creek. All samples were preserved with 70% ethanol, transported to the laboratory, the macroinvertebrates separated from debris, and the specimens then stored in polyethylene bottles with 70% ethanol until identified. Robert W. Paul identified the macroinvertebrates to family level using Peckarsky et al. (1990) and Jessup et al. (2002) as authorities. Individuals were counted, tallied, and entered into a spreadsheet in Microsoft Excel.

Fish were collected at all non-tidal sites from July 14 through July 25, 2008. Thirteen of the fifteen non-tidal SMRP sites were sampled for fish using MBSS protocols (Kayzak, 1997). The two non-tidal sites not sampled were NT01- Locust Grove Cove, a site that is actually brackish, and NT04, St. Mary's Lake). Electroshocking was used to sample in 75 m segments designated at each of the SMRP non-tidal stations. A Smith-Root Model LR-24 Electrofisher 24-volt shocking system was used for sampling. All individuals were identified to species using Kayzak, et al. (2003) and Page and Burr (1991) as authorities. Once fish were indentified, they were weighed, and released.

Results

Water Quality Results

Tidal water quality taken with the YSI 6600 sonde was not noticeably different between the surface (0.5 m) and depth (3.0 m) (Figures 2 and 3). However, chlorophyll *a* and percent dissolved oxygen were clearly higher and lower, respectively, on the June 11, 2008 sampling date (Figure 3). This is significant because storm events in mid-May (5/9-5/12 and again on 5/14-15) clearly influenced lowered water temperature and salinity at the dock site (Figure 2). This, in turn, created an algal bloom that sank or developed near the bottom, which depressed the Secchi disk depth and dissolved oxygen concentration in the water on May 14th. We have always strongly suspected that storm events cause rather dramatic changes in St. Mary's River tidal water quality, but we have not had a set of data where the parameters were so closely linked. It is likely that May 14th nutrient data will also reflect the events.

CBL NUTRIENT RESULTS HAVE NOT BEEN RETURNED.

Table 3. Tidal water quality results taken from the St. Mary's College dock on a biweekly basis from May through August 2008. All values are mg/L except Secchi disk depth which is in m.

	5/14/08	5/28/08	
SECCHI	1.06	1.5	Missing DATA
CHLA	-	-	
DOC	4.93	3.87	
NH4F	0.07	0.031	
NO2F	0.0046	0.0085	
NO23F	0.0746	0.127	
PC	3.04	1.24	
PIP	0.0137	0.0074	
PN	0.423	0.228	
PO4F	0.0039	0.0032	
PP	0.0304	0.0193	
TDN	0.51	0.45	
TDP	0.0143	0.0142	
TSS	64.5	48.7	
VSS	10.5	7.5	

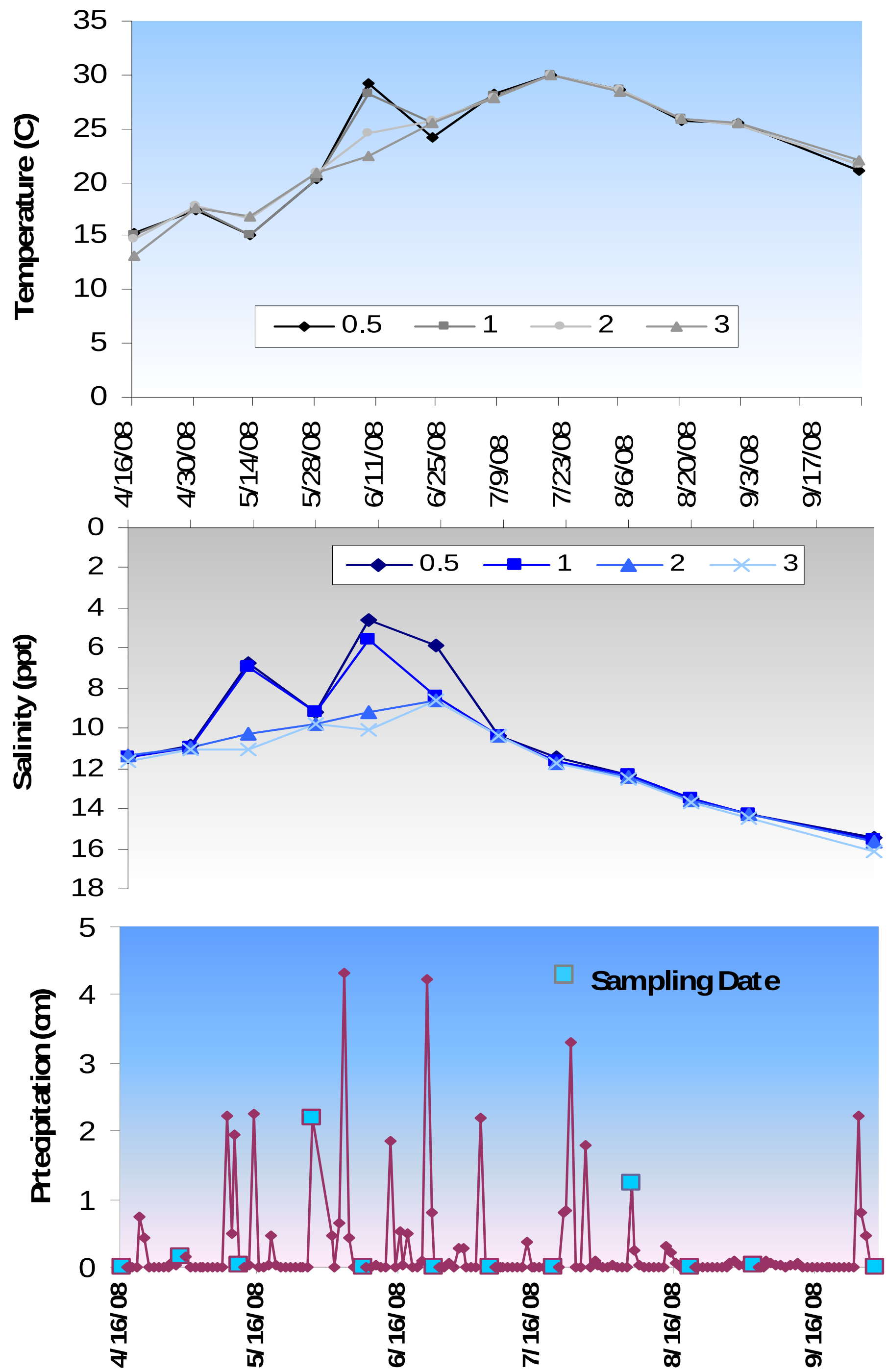

Figure 2. Water temperature, salinity, and precipitation at St. Mary's College dock throughout the study period, April 15-September 30, 2008, with sampling dates highlighted.

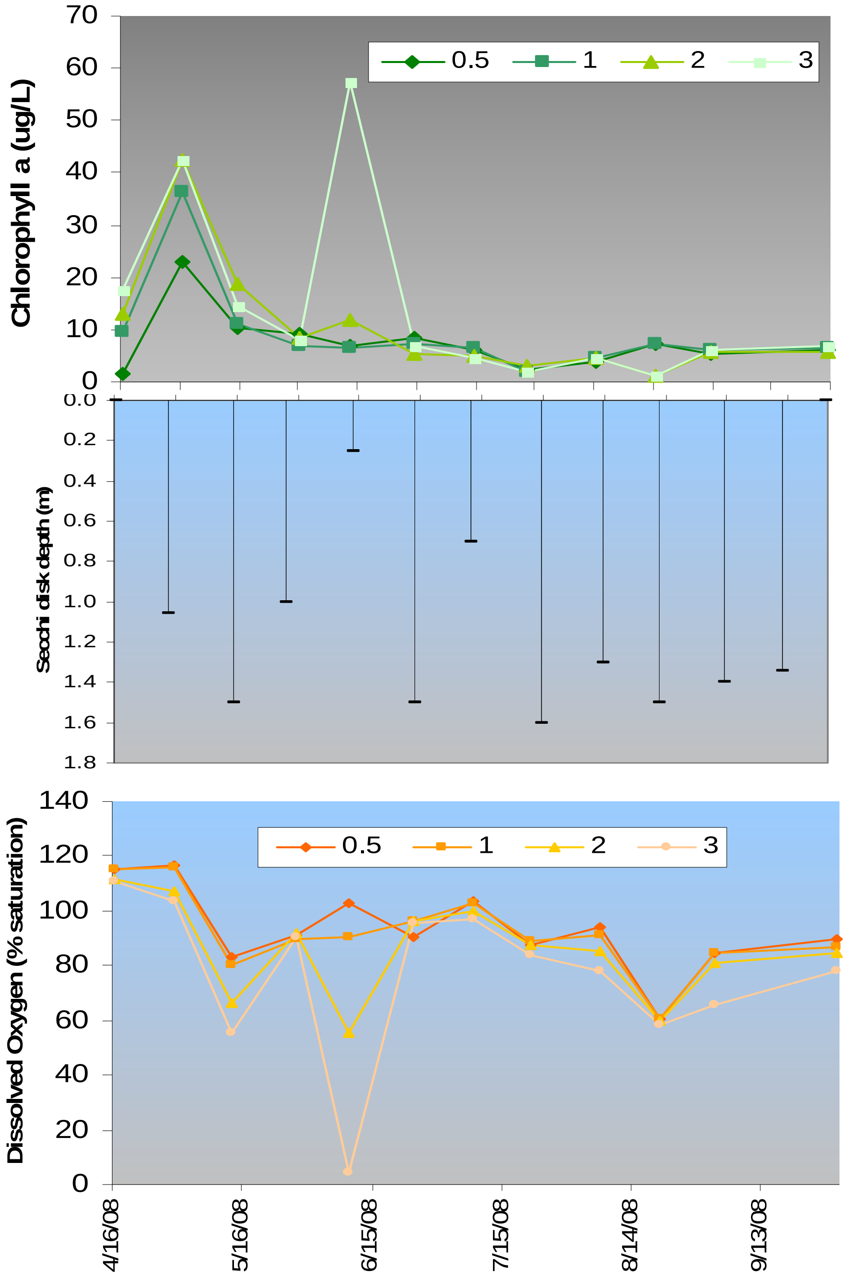

Figure 3. Chlorophyll *a*, and percent saturation of dissolved oxygen at 0.5, 1.0, 2.0, and 3.0 m depths, and Secchi disk depth at St. Mary's College dock throughout the study period, April 15-September 30, 2008.

Non-tidal results were consistent except for the two stations which have lentic (standing water) attributes, NT01- Locust Grove Cove and NT04 – St. Mary's Lake (Table 3). For example, surface water temperatures at these two stations were considerably higher than those at stream sites. Sulfate (SO_4) levels reflect the tidal nature of Station NT01 and high dissolved organic carbon (DOC), particulate carbon (PC), particulate inorganic phosphorus (PIP), total dissolved phosphorus (TDP), and orthophosphate (PO_4) concentrations point to high algal growth/eutrophic conditions at NT01. In addition, water quality problems were indicated by NT01's very low dissolved oxygen content, and these problems are a historic problem at this station (Paul, 2006).

Nutrients were generally low and below levels of concern at all non-tidal sites (Table 4). The only exceptions were NT06 (Hickory Hills Tributary) and NT 9.5 (Johns Creek) which had nitrite-nitrate levels slightly above1.0 mg/L. TSS and TVS were proportional to each other with the exception of those at NT10 (Hilton Run) where TVS concentrations were low relative to TSS, indicating a higher inorganic fraction in the TSS sample. Relatively high sediment loads are being carried by Hilton Run (NT10) and Church Creek (NT14) as they both had TSS concentrations above 80 mg/L under low flow conditions. All other non-tidal stations had TSS levels well below the concern threshold of 50 mg/L.

We also tried to coordinate our non-tidal water quality data collection with Niles Primrose of the Maryland Department of Environment (MDE), but we were unable to make collections together in September under low flow conditions. MDE sampled extensively (61 sites) in the watershed on February 27 and 28, 2008, prior to the start of this survey, and Mr. Primrose supplied these data to us. MDE sites corresponded to 10 of the 15 SMRP stations. The results from MDE's sampling in February are not specifically comparable to samples that we took in July, but they are shown in Table 5.

The results of nutrient analyses at common sites were, however, possible. What is interesting about the data at the 10 common stations is there consistency (Figure 2). Nitrogen (nitrite-nitrate and total N), green, and phosphorus (orthophosphate and total P), grey, concentrations were remarkably similar considering that the samples were collected in February and in July and by different, uncoordinated teams. Clearly, the NT01 (MDE #SM52) station on Locust Grove Cove showed exceptionally high nutrients relative to the other sites. This site has been sampled by SMRP routinely for 10 years, and we have obtained similar results to the synoptic survey and the MDE survey.

While the other sites have reduced nutrient concentrations compared to NT01, both nitrogen and phosphorus results were remarkably similar in their relative concentrations. The synoptic survey-MBSSA results comparison was not especially useful in an absolute sense, but these data do confirm the validity of both sets of data, and do validate the relative nutrient concentrations at the various stations.

Table 4. Non-tidal water quality results from all stations on July 10 and 11, 2008. Missing values are due to contamination or sampling errors. Station NT04, St. Mary's Lake, was sampled at the surface and at 1 m depth.

SITE	NH_4	NO_2	NO_{23}	TDN	PO_4	PP	PIP	TDP	PNA	PC	DOC	SO_4	TSS	TVS
NT01	0.020	0.0006	0.0066	1.41	0.0570	0.2745	0.0794	0.1700	0.854	5.160	21.55	9.21	20.8	18.8
NT02	0.034	0.0024	0.5460	.	0.0044	0.0101	0.0048	.	0.059	0.672	5.23	6.56	6.5	5.0
NT03	0.059	0.0006	0.0067	0.58	0.0006	0.0171	0.0141	0.0114	0.205	1.750	11.78	5.32	19.3	10.0
NT04	0.003	0.0006	0.0047	0.75	0.0011	0.0122	0.0048	0.0140	0.198	1.840	10.33	4.76	6.0	6.0
NT05	0.165	0.0360	0.5636	1.34	0.0037	0.0256	0.0046	0.0128	0.062	0.642	5.34	4.76	4.0	3.0
NT06	0.024	0.0027	1.2350	1.82	0.0028	0.0032	0.0024	0.0138	0.035	0.375	3.81	7.18	2.7	2.5
NT07	0.024	0.0042	0.5225	1.02	0.0059	0.0232	0.0024	0.0223	0.067	0.829	6.31	-	14.3	5.7
NT08	-	-	0.4484	1.00	-	0.0054	0.0024	0.0217	-	-	5.33	-	5.8	2.5
NT09	0.018	0.0018	0.3680	-	0.0013	0.0029	0.0024	-	0.040	0.542	6.55	5.38	2.4	3.5
NT9.5	0.012	0.0028	1.7100	1.75	0.0057	0.0057	0.0025	0.0220	0.039	0.396	3.41	7.83	2.4	3.5
NT10	0.035	0.0018	0.1869	0.66	0.0030	0.0510	0.015	0.0216	-	-	6.89	5.80	82.0	9.0
NT11	0.019	0.0017	0.4204	0.89	0.0032	0.0192	0.0194	0.0185	0.224	1.710	5.71	7.31	28.5	7.3
NT12	0.084	0.0020	0.9853	1.33	0.0098	0.0046	0.0024	0.0124	0.032	0.422	3.06	3.82	4.3	2.5
NT13	0.050	0.0013	0.2173	0.66	0.0037	0.0082	0.0061	0.0196	0.094	1.370	6.22	12.63	8.0	4.2
NT14	0.046	0.0029	0.2860	-	0.0054	0.0643	0.0684	-	0.385	5.030	8.27	6.82	84.0	14.8

SITE	WTEMP	DO	DO_SAT	pH	SPCOND	WTEMP	DO	DO_SAT	pH	SPCOND
NT01	27.26	3.95	49.7	7.07	47					
NT02	21.32	8.08	91.2	7.38	81					
NT03	22.34	7.71	88.8	6.76	14	1 m	1 m	1 m	1 m	1 m
NT04	28.21	7.28	93.5	6.82	33	27.46	6.56	83.3	6.45	35
NT05	21.16	7.32	85.9	7.19	103					
NT06	22.54	7.54	86.2	7.27	103					
NT07	23.83	7.53	89.2	7.14	40					
NT08	21.87	8.12	92.7	6.85	60					
NT09	21.84	7.74	88.8	6.89	47					
NT9.5	20.88	8.96	100.3	7.39	79					
NT10	22.14	8.34	95.9	7.18	60					
NT11	22.55	7.65	91.2	6.50	50					
NT12	20.68	8.11	90.5	6.28	48					
NT13	21.11	7.76	87.3	6.06	76					
NT14	21.94	6.87	81.5	6.33	47					

Table 5. Water quality data at common at MDE and Synoptic Survey stations.

		MDE Results							
MDE #	SMRP #	Temp (C)	DO (mg/L)	pH	Conduct. (mhos/cm^2)	PO_4 (mg/L)	NO_{23} (mg/L)	TP (mg/L)	TN (mg/L)
SM52	NT01	4.8	12.00	5.80	0.187	0.0063	0.003	0.081	0.83
SM45	NT02	5.4	11.90	5.60	0.120	0.0024	0.804	0.012	1.04
SM59	NT03	9.0	8.90	7.80	0.080	0.0025	0.155	0.021	0.64
SM23	NT08	6.5	11.21	5.56	0.097	0.0023	0.481	0.015	0.80
SM43	NT09	2.6	12.60	5.40	0.092	0.0035	0.894	0.014	0.79
SM41	NT9.5					0.0035	1.460	0.016	1.58
SM19	NT10	4.3	10.73	6.05	0.101	0.0023	0.263	0.012	0.40
SM16	NT11					0.0007	0.507	0.013	0.58
SM11	NT13								
SM1	NT14	6.6	10.90	6.20	0.139	0.0028	0.645	0.006	0.73
		Synoptic Survey Results							
SITE	MDE #	Temp (C)	DO (mg/L)	pH	Conduct. (uhos/cm^2)	PO_4 (mg/L)	NO_{23} (mg/L)	TDP (mg/L)	TDN (mg/L)
NT01	SM52	27.26	3.95	7.07	47	0.0570	0.0066	0.170	1.41
NT02	SM45	21.32	8.08	7.38	81	0.0044	0.5460	.	.
NT03	SM59	22.34	7.71	6.76	14	0.0006	0.0067	0.011	0.58
NT08	SM23	21.87	8.12	6.85	60	-	0.4484	0.022	1.00
NT09	SM43	21.84	7.74	6.89	47	0.0013	0.3680	-	-
NT9.5	SM41	20.88	8.96	7.39	79	0.0057	1.7100	0.022	1.75
NT10	SM19	22.14	8.34	7.18	60	0.0030	0.1869	0.022	0.66
NT11	SM16	22.55	7.65	6.50	50	0.0032	0.4204	0.019	0.89
NT13	SM11	21.11	7.76	6.06	76	0.0037	0.2173	0.020	0.66
NT14	SM1	21.94	6.87	6.33	47	0.0054	0.2860	-	-

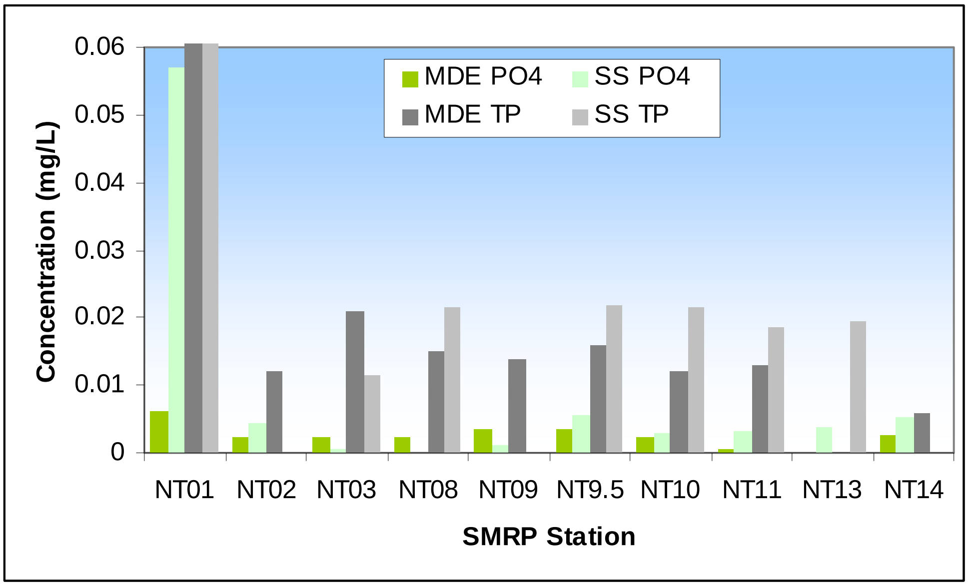

Figure 4. Comparison of nitrogen (NO_{23} and TN) and phosphorus (PO_4 and TP) at stations sampled by the Maryland Department of Environment (MDE) on February 27 and 28, 2008, to the same stations sampled during the synoptic survey (SS) on July 10 and 11, 2008.

Biological Results
Macroinvertebrates

Macroinvertebrates have been collected at non-tidal stations in the St. Mary's River Project (SMRP) in the spring of 1999, 2000, 2001, 2003, and 2008, however the specific stations sampled in each of these years was different (Table 6). In addition, three new stations, not previously sampled, were added in 2008: on Indian Bridge Road just below the bridge crossing the St. Mary's River (Below IRB), the St. Mary's River at the kayak launch park in Great Mills (Kayak Park), and Craney Creek. In 2008, a total of 536 individuals in 36 families and 8 orders were obtained in kick net samples (Table 7). By comparison, in all the SMRP studies from 1999 through 2006, 57 families of aquatic insects have been found at St. Mary's River watershed non-tidal stations. Therefore, the collections made in 2008 seem to be good representations of macroinvertebrates based on our historic sampling and because a comprehensive study of aquatic insects (Boward et al., 1998) found 56 families of insects in the entire lower Potomac watershed.

When we compared all the insects collected in 2008 by order (Figure 3), we found that Diptera (31.6%) and Ephemeroptera (29.7%) were the most common orders followed by Odonata (14.0%), Plecoptera (9.6%), Trichoptera (7.9%), and Coleoptera (6.3%). Megaloptera (0.8%) and Hemiptera (0.2%) were relatively rare in the 2008 samples. The number of insect families at each station in 2008 was variable with between 4 and 20 families (Table 7). Generally, the insects found reflected specific stream conditions. When we examined the aquatic insect results by station (Figure 6), it was readily apparent that Craney Creek had a poor community as represented by few insects and minimal diversity. NT06 (Hickory Hills) and NT11 (Pembrooke Run) also had reduced numbers relative to the other stations, but the results were not as bad as found at Craney Creek.

The EPA Rapid Bioassessment Protocol for Use in Streams and Rivers (Plafkin et al., 1989) uses community diversity in assessing water quality. The absence of pollution sensitive aquatic insect orders (Ephemeroptera, Plecoptera, and Trichoptera) and dominance of pollution-tolerant groups (Oligochaetes or Chironomids), is indicative of pollution. The presence or absence of aquatic insect indicators or of an indicator species or indicator community reflects environmental conditions. Absence of a species is not as meaningful as it might seem as there may be reasons, other than pollution, that result in a species absence (e.g., predation, competition, or geographic barriers which prevented it from ever being at the site). Absence of multiple species of different orders with similar tolerance levels that were present previously at the same site is more indicative of pollution than absence of a single species. In addition, it is clearly necessary to know which species should be found at a site or in a system.

Table 6. Non-tidal stations sampled for macroinvertebrates (X) each year in the St. Mary's River watershed.

		Year Sampled				
Site #	Site Name	1999	2000	2001	2003	2008
NT01	Locust Grove		X			
NT02	Warehouse Run	X	X	X	X	X
NT03	Below SM Lake	X	X	-	-	-
NT05	Landfill Trib	-	X	X	X	X
NT06	Hickory Hills	X	X	X	X	X
NT07	Norris Road	X	X	X	-	-
NT08	Jarboesville Run	X	X	X	-	-
NT09	US Gauging Station	X	X	X	-	-
NT09.5	Johns Creek	-	-	X	-	X
NT10	Hilton Run	X	X	X	X	X
NT11	Pembrook Run	X	X	X	X	X
NT12	Eastern Branch	X	X	X	-	-
NT13	Fisherman's Creek	X	X	X	X	-
NT14	Church Creek	-	X	X	-	-
NT12	Eastern Branch	X	X	X	-	-
NT13	Fisherman's Creek	X	X	X	X	-
NT14	Church Creek	-	X	X	-	-
New	St. Mary's R. at Kayak Park	-	-	-	-	X
New	St. Mary's River below Indian River Bridge	-	-	-	-	X
New	Craney Creek	-	-	-	-	X

Overall, low richness of benthic macroinvertebrates may indicate impairment. However, naturally low nutrient levels in pristine headwaters may be the cause of low productivity and few benthic macroinvertebrate species exist in these conditions. While there are many insect species that serve as excellent indicators of both good and poor water quality, the identification of aquatic insects to the species level is difficult and requires specialized training. More general appraisals, such as the proportion of Ephemeroptera, Plecoptera, and Trichoptera (EPT) families to all other families are a relatively good measure of the aquatic insect community's health. While Maryland DNR uses the more sophisticated Index of Biological Integrity (IBI) to assess the health of macroinvertebrate communities (e.g. Roth et al., 1996; Boward et al., 1998), there were difficulties in our using this index to compare our results over the nearly 10- year SMRP time span. The problems arose primarily because different metrics were apparently used to compute IBI scores in different years. Therefore, we opted to compute the less sophisticated EPT ratios in order to compare our St. Mary's River watershed stations in 2008.

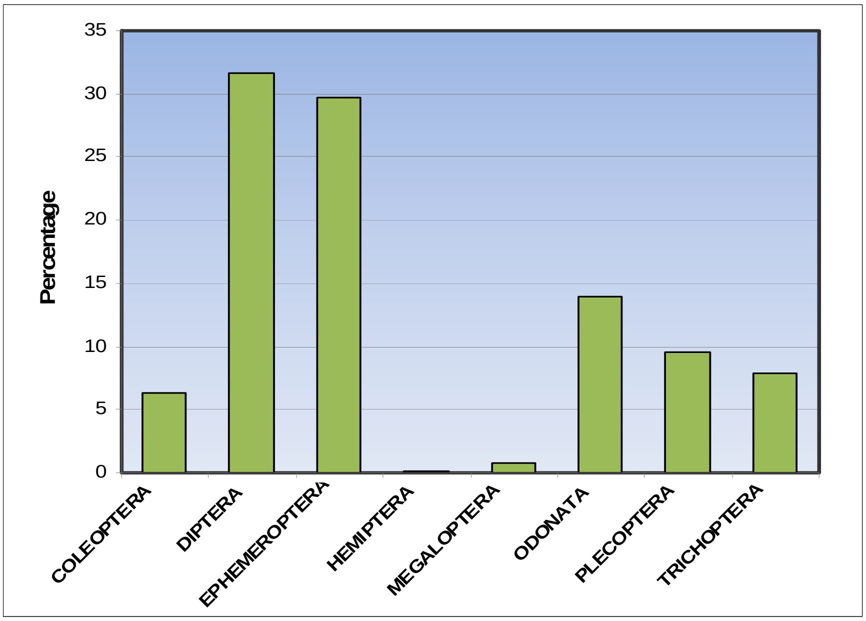

Figure 5. Percentage of insects in each order collected from all sites in 2008.

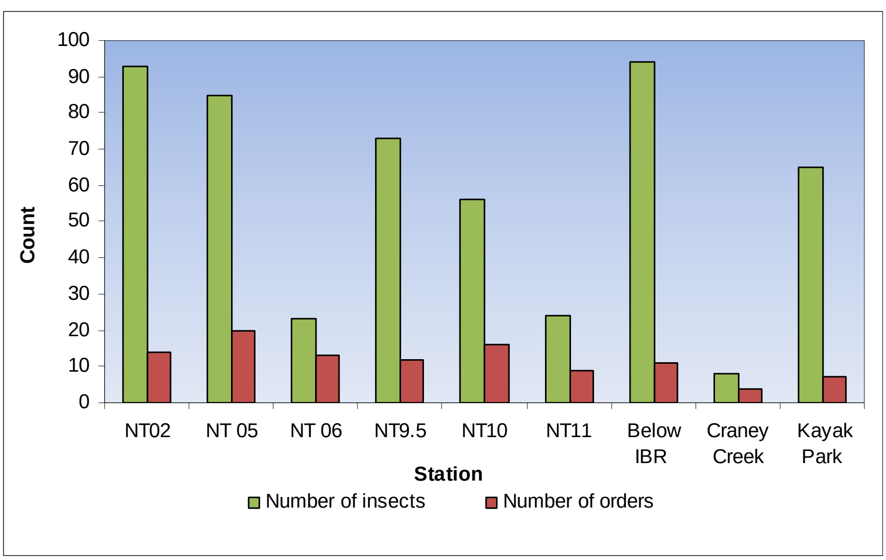

Figure 6. Number of insects and number of orders found at each sampling station in April of 2008.

Table 7. Number of macroinvertebrates collected in each family at each site in 2008.

Order	Family	NT02	NT 05	NT 06	NT9.5	NT10	NT11	Below IBR	Craney Creek	Kayak Park	Total	Percent
COLEOPTERA	Gyrinidae	3	4	2	0	0	0	3	0	0	12	2.30
COLEOPTERA	Psephenidae	0	2	0	0	1	0	0	0	0	3	0.57
COLEOPTERA	Dryopidae	0	2	0	0	0	0	0	0	0	2	0.38
COLEOPTERA	Veliidae	0	1	0	0	0	0	0	0	0	1	0.19
COLEOPTERA	Elmidae	0	7	0	0	7	1	0	0	0	15	2.87
DIPTERA	Tabanidae	3	0	1	0	1	0	4	0	0	9	1.72
DIPTERA	Chironomidae	69	16	2	19	5	2	6	3	15	137	26.25
DIPTERA	Pupa	1	0	0	0	0	0	0	0	0	1	0.19
DIPTERA	Tipulidae	1	0	0	1	3	0	1	0	12	18	3.45
EPHEMEROPTERA	Baetidae	1	0	1	8	1	0	48	0	0	59	11.30
EPHEMEROPTERA	Ephemerellidae	0	0	3	0	0	0	0	0	0	3	0.57
EPHEMEROPTERA	Heptageniidae	0	25	4	3	0	6	18	0	22	78	14.94
EPHEMEROPTERA	Leptophlebiidae	0	0	0	0	0	2	0	0	0	2	0.38
EPHEMEROPTERA	Metretopodidae	0	0	0	0	0	1	0	0	0	1	0.19
EPHEMEROPTERA	Tricorythidae	0	0	0	0	12	0	0	0	0	12	2.30
HEMIPTERA	Saldidae	0	0	0	0	1	0	0	0	0	1	0.19
MEGALOPTERA	Corydalidae	0	1	0	0	2	0	0	0	0	3	0.57
MEGALOPTERA	Sialidae	0	1	0	0	0	0	0	0	0	1	0.19
ODONATA	Aeshnidae	1	5	1	0	4	0	1	0	0	12	2.30
ODONATA	Cordulegastridae	1	0	1	1	0	0	0	0	0	3	0.57
ODONATA	Corduliidae	0	1	0	2	0	1	0	0	0	5	0.96
ODONATA	Gomphidae	1	0	0	0	2	0	1	2	1	7	1.34
ODONATA	Calopterygidae	1	3	0	4	3	0	0	0	0	11	2.11
ODONATA	Coenagrionidae	1	3	2	12	2	3	0	0	0	23	4.41
ODONATA	Lestidae	0	1	0	0	1	7	0	0	0	9	1.72
ODONATA	Gomphidae	0	2	0	0	0	1	0	0	0	3	0.57
PLECOPTERA	Chloroperlidae	1	3	2	12	0	0	0	0	0	18	3.45
PLECOPTERA	Perlidae	1	2	2	7	4	0	2	0	2	20	3.83
PLECOPTERA	Perlodidae	0	0	0	0	0	0	0	0	12	12	2.30
TRICHOPTERA	Hydropsychidae	8	2	1	3	0	0	9	0	0	23	4.41
TRICHOPTERA	Limnephilidae	0	1	0	0	0	0	1	1	0	3	0.57
TRICHOPTERA	Phryganeidae	0	0	0	0	0	0	0	2	0	2	0.38
TRICHOPTERA	Polycentropodidae	0	3	1	1	7	0	0	0	1	13	2.49
Total number of individuals		**93**	**85**	**23**	**73**	**56**	**24**	**94**	**8**	**65**	**522**	
Total number of families		**14**	**20**	**13**	**12**	**16**	**9**	**11**	**4**	**7**		

The numbers of insects in EPT orders was quite variable with NT11 lacking both Ephemeroptera and Trichoptera, and Craney Creek lacking both Ephemeroptera and Plecoptera (Figure 5, Table 7). Clearly, both these stations, in general, had poor diversity. Most of the other stations, with the exceptions of NT 02 and NT 9.5, had total EPT counts comprised mostly of Emphemeroptera. A comparison of insects at each site

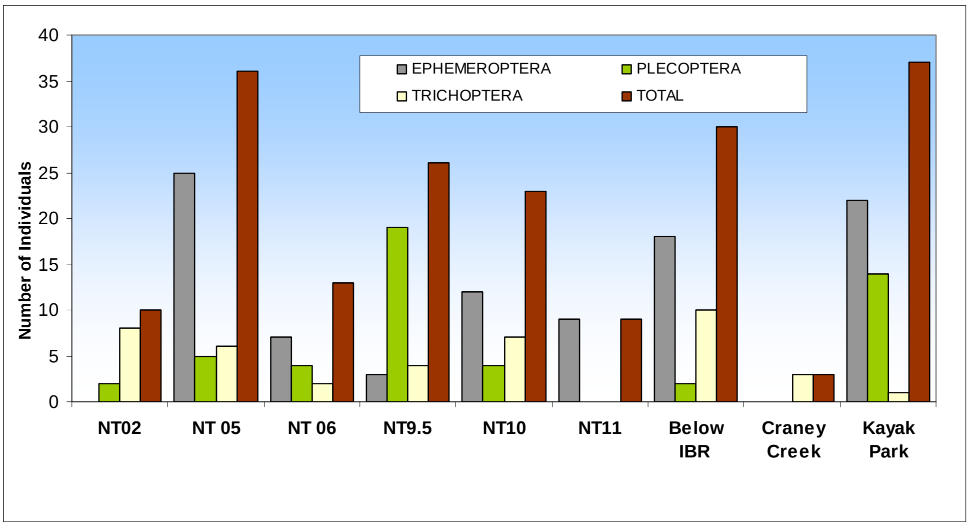

Figure 7. Total number of individuals in Ephemeroptera, Trichoptera, and Plecoptera orders from all stations sampled in the spring of 2008.

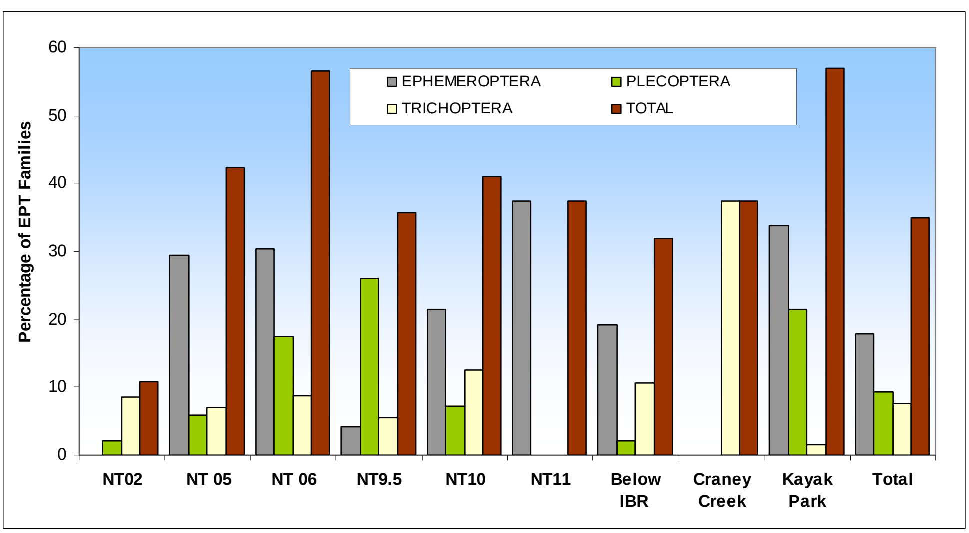

Figure 8. Percentage of Ephemeroptera, Trichoptera, and Plecoptera (ETP) families from all stations in the Spring of 2008. Total bars represent the percentage of EPT families to all other families at each station.

in 2008 by their proportion of EPT (Figure 8) indicated that all stations except NT02 had at least 30% of their total count in EPT orders. The mean percentage of EPT in all samples was 37.4% for all stations. Yet, some of these results are misleading when EPT proportions were compared to total numbers of individuals and families. For example, the lowest aquatic insect abundance (8 individuals) and the fewest taxa (4) occurred at Craney Creek. However, at this site 3 of the 8 individuals were trichopterans giving a false impression of high insect diversity based on the EPT ratio (37.5%). This is the first year that Craney Creek was sampled for insects, and the site is not monitored for water quality. Therefore, it is difficult to determine whether this site is perturbed or has historical problems. Stations NT06 and NT11 also had few insects with 23 and 24 individuals, respectively; however, both had high EPT percentages. NT06 had 56.5% EPT and NT11 had 41.1%. The only other time that NT06 was sampled for insects was in the year 2000, and that sample also yielded 23 individuals (Paul and Tanner, 2004). Site NT11, by contrast, had 78 individuals in 2005, so the high EPT percentage at this site is an anomaly especially with both Plecoptera and Trichoptera entirely absent in 2008.

The highest numbers of individuals (94) were found at the Below IBR station. The next highest numbers were at NT02 (93 individuals), and at NT05 (85 individuals). Despite the high number of insects at NT02, the site had an EPT percentage of only 10.8, the lowest of any of the sampled stations and no mayflies (Emphemeroptera) were found there.

There were also other confusing results. The Below IBR site had a fairly low EPT ratio of 31.9%, despite having the highest number of insects (94 individuals). NT05 (Landfill Tributary), had the most surprising results of all because it had a large number (85) of insects (Figure 5) and a 42.3% EPT ratio (Figure 6). These results are curious because the station is characterized by very heavy bank erosion and siltation, and these conditions were coupled with very high ammonia concentrations relative to all other stations (Table 3). In addition, this station has had historic water quality problems, yet this station has had relatively high aquatic insect densities in past years (90 individuals in 2000) but low densities (the number dropped to 32 in 2005) as well (Paul, 2006; Paul and Tanner, 2001, 2005).

In general, many of these results echo the results found in previous years. Aquatic insect abundance, diversity and community structure found in the 2008 collections support SMRP results and those of MBSS studies (Boward et al. 1998; Stranko and Rodney, 2001). The 2008 aquatic insect results also reflect the current physical and chemical conditions at non-tidal St. Mary's River stations. The anomalies encountered in 2008 at some stations might be explained by repeated sampling at these stations in the future.

Fish

A total of 817 individual fish belonging to26 species and representing 10 families were collected in 2008 (Table 8). Tessellated darters (24%) and American eels (20%) were the most common species, while the percentage of Red-breasted sunfish (5%) and Least brook lampreys (6%) were considerably lower in number from the previous collections. Petromyzonidae (eels), Anguillidae (lampreys), Centrachidae (sunfish) and Percidae (darters) when combined made up 70% of all fish collected (Figure 7). Over a third (13 out 41) of all species collected in 2008 were relatively rare and were collected at 3 or fewer stations out of 13 total stations (Table 8).

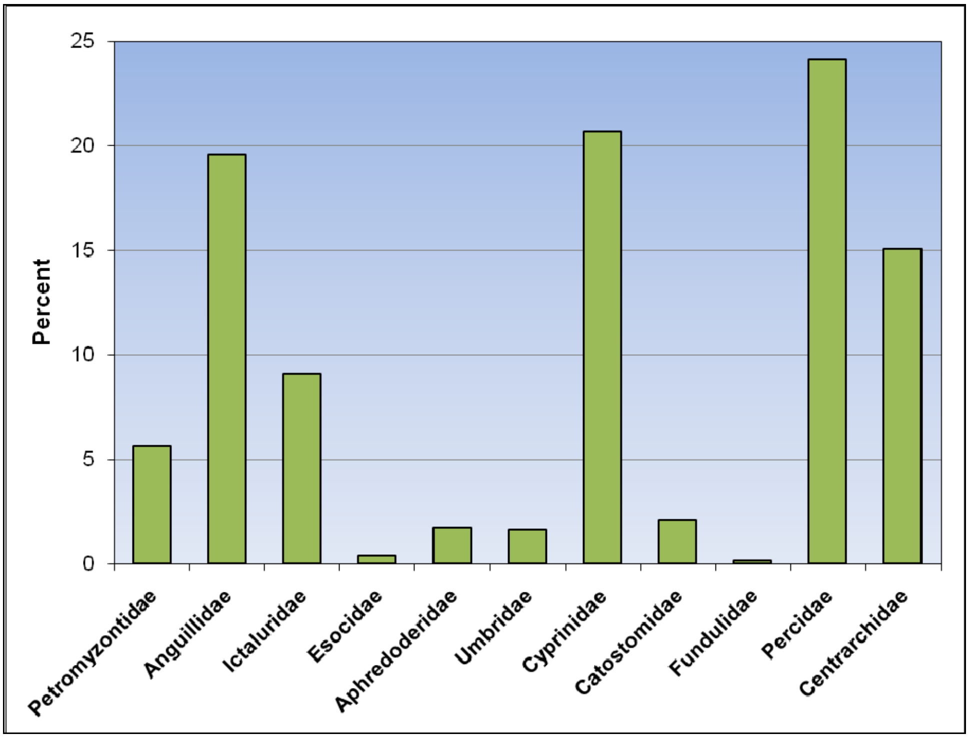

Figure 9. Families of fish collected in August of 2008 as a percentage of the total fish collected.

Table 8. Total number of fish by family collected at all non-tidal stations in July of 2008.

Family - Species	**Common name**	**NT 02**	**NT 03**	**NT 05**	**NT 06**	**NT 07**	**NT 08**	**NT 09**	**NT 9.5**	**NT 10**	**NT 11**	**NT 12**	**NT 13**	**NT 14**	**Total**
Petromyzontidae															
Lampetra aepyptera	(Least Brook Lamprey)	7	0	2	2	1	1	7	6	2	1	7	10	0	46
Anguillidae															
Anguilla rostrata	(American eel)	21	13	7	11	6	6	22	3	6	14	12	17	22	160
Ictaluridae															
Ameiurus nebulosus	(Brown Bullhead)	0	0	0	0	0	0	0	3	0	0	0	21	3	27
Noturus gyrinus	(Tadpole Madtom)	1	16	1	0	0	0	4	2	0	0	5	0	0	29
Noturus insignis	(Margined Madtom)	0	2	1	2	1	0	4	1	5	0	2	0	0	18
Esocidae															
Esox niger	(Chain Pickerel)	0	0	0	0	0	0	0	0	0	1	0	2	0	3
Aphredoderidae															
Aphredoderus sayanus	(Pirate Perch)	7	0	0	0	0	0	0	3	4	0	0	0	0	14
Umbridae															
Umbra pygmaea	(Eastern Mudminnow)	6	0	0	1	0	0	1	2	0	0	0	2	1	13
Cyprinidae															
Cyprinella spiloptera	(Spotfin Shiner)	0	13	3	6	5	0	6	4	0	0	0	0	0	37
Luxilus chrysocephalus	(Striped shiner)	0	1	0	0	0	0	3	13	0	0	0	0	0	17
Notemigonus crysoleucas	(Golden Shiner)	1	1	0	0	0	0	0	8	0	0	0	3	0	13
Notropis amoenus	(Comely Shiner)	0	0	0	0	0	0	0	0	0	2	2	0	0	4
Notropis procne	(Swallowtail shiner)	0	0	0	0	0	0	0	0	0	15	1	0	0	16
Rhinicthys atratulus	(Blacknose dace)	3	0	0	0	0	0	1	30	0	0	0	0	0	34
Notropis bifrenatus	(Bridal shiner)	0	1	0	0	0	0	11	30	1	0	5	0	0	48

Table 8 (continued).

Family - Species	Common name	NT 02	NT 03	NT 05	NT 06	NT 07	NT 08	NT 09	NT 9.5	NT 10	NT 11	NT 12	NT 13	NT 14	Total
Catostomidae															
Moxostoma erythrurum	(Golden Redhorse)	0	0	0	0	0	0	0	0	0	0	0	8	0	8
Moxostoma macrolepidotum	(Shorthead redhorse)	4	0	0	0	1	0	2	1	1	0	0	0	0	9
Fundulidae															
Fundulus heteroclitus	(Mummichog)	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Percidae															
Etheostoma flabellare	(Fantail darter)	0	0	0	0	0	0	0	0	0	1	0	0	0	1
Etheostoma olmstedi	(Tessellated Darter)	27	9	1	16	10	8	35	66	0	17	7	0	0	196
Centrarchidae															
Lepomis auritus	(Redbreast Sunfish)	6	1	5	2	4	0	12	7	2	3	1	0	0	43
Lepomis cyanellus	(Green sunfish)	2	0	0	0	0	0	0	8	0	0	2	0	0	12
Lepomis gibbosus	(Pumpkinseed)	7	0	2	0	0	2	1	4	0	0	0	8	5	29
Lepomis macrochirus	(Bluegill)	0	5	12	4	1	0	3	0	1	0	0	0	8	34
Lepomis punctatus	(spotted sunfish)	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Micropterus salmoides	(Largemouth Bass)	1	1	0	0	0	0	0	0	0	0	0	0	2	4
Total number of fish		93	63	34	44	29	17	112	191	22	54	44	71	43	817
Number of species		10	11	9	8	8	4	14	17	8	8	10	8	8	26

Table 9. Non-tidal stations sampled for fish (X) during the MBSS Summer Index Period.

Site #	Site Name	1999	2000	2001	2003	2005	2008
NT02	Warehouse Run	X	-	X	X	X	X
NT03	Below SM Lake	X	-	-	-	-	X
NT05	Landfill Trib	-	X	X	X	X	X
NT06	Hickory Hills	X	-	X	X	-	X
NT07	Norris Road	X	-	X	X	-	X
NT08	Jarboesville Run	X	-	X	-	-	X
NT09	US Gaging Station	X	-	X	-	-	X
NT09.5	Johns Creek	-	-	X	-	-	X
NT10	Hilton Run	X	-	X	X	X	X
NT11	Pembrook Run	X	X	X	X	X	X
NT12	Eastern Branch	X	-	X	-	-	X
NT13	Fisherman's Creek	X	X	X	X	-	X
NT14	Church Creek	-	X	X	-	-	X

Since 1999 the number of non-tidal stations sampled for fish during the MBSS Summer Index Period has not been consistent, but nearly all stations were collected in 1999, 2001, and 2008 (Table 9). Over the entire study period (1999-2008), a total of 6,612 individual fish representing 11 families and 41 species have been collected and identified (Paul, 2006, plus this synoptic survey). Nearly 80% of all fish collected in both 1999 and 2001 were very common: American eel (27%, 19%), Least brook lamprey (19%, 29%), Tessellated darter (19%, 16%) and Red-breasted sunfish (12%, 9%), respectively for 1999 and 2001 (Table 10). When 1999 and 2001 data were compared, many of the same species were found again at the second sampling in 2001. For example, at NT06 (Hickory Hills) 13 species were reported in 1999 and 12 species in 2001 and 10 were in common for both years.

Yet, some 1999 and 2001 data comparisons also show some anomalies. For example, no Largemouth bass were collected in 1999 but in 2001 10 were captured at five sites, and in 2008 only 4 Largemouth bass were collected at only 3 stations, NT02, NT03, and NT14. Some changes were seen between the 2008 data and those of previous years. A large decrease was seen in the percentage of Least brook lampreys. In 1999, 19% of all fish sampled were Least brook lampreys, in 2005 they constituted 24.1% of fish, but by 2008 their percentage had shrunk to only 5.6%. It is possible that this was affected by conditions unrelated to the habitat of the streams, such as sampling efficiency. Many of the stations (for example, NT02, NT08, and NT12) that had 100 individuals at each station in 1999 had less than 10 individuals in 2008 (Table 10).

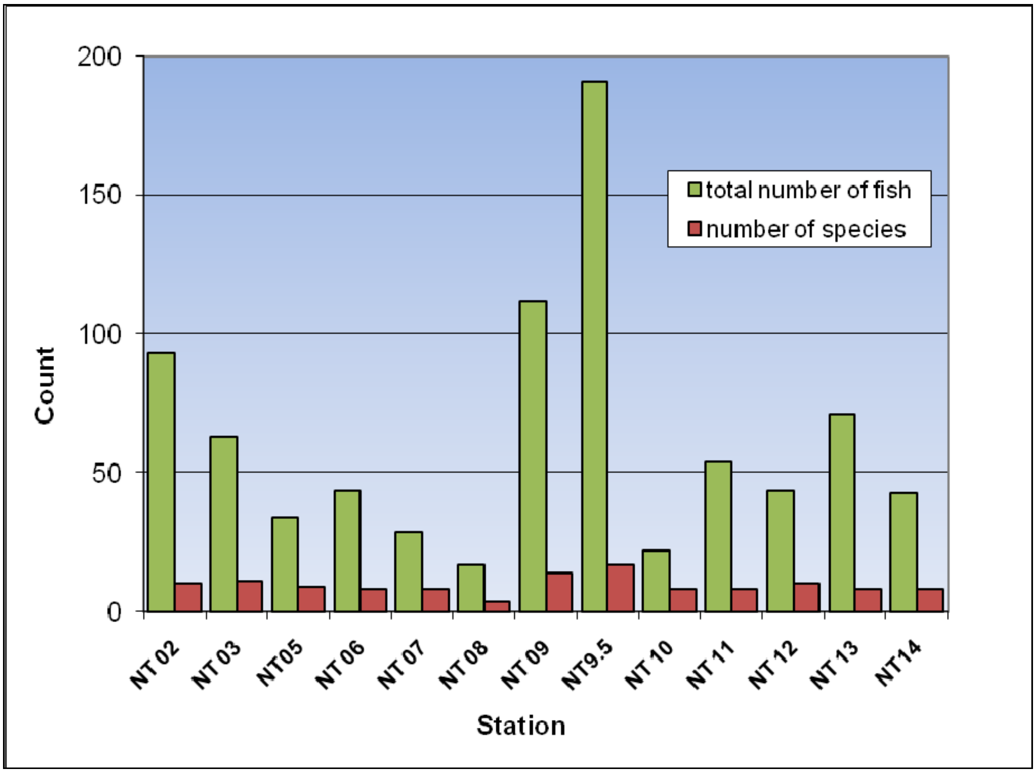

Figure 10. Total number of fish and number of species collected at all non-tidal station during August of 2008.

In a 1995 fish survey of the lower Potomac watershed by the Maryland Biological Stream Survey (MBSS) of DNR, 73 sites (including 2 in the St. Mary's River watershed: Jarboesville Run-NT08 and Pembrook Run-NT11) yielded 41 species in 13 families (Boward et al., 1998). In this study, just 6 species of fish represented 75% of the total abundance. Three of these species were common in both the Lower Potomac study and our St. Mary's River watershed study: American eel, Least brook lamprey, and Tessellated darter. An analysis of the fish found in the 1995 MBSS study and our 1999 and 2001 samples for Jarboesville Run (NT08) showed complete agreement, as all 3 samples had the same 12 species. However, there was strong disagreement in the results for Pembrook Run.

Again, when we looked at our fish results across all years of sampling (Table 10) we found that all sites (except for NT13- Fisherman Creek which had only 4 species) had at least 9 fish species and 100 individuals in 1999. These results lead us to believe the fish communities were healthy except for Fisherman Creek. But in subsequent years through 2005, the number of species collected at Fishermans Creek increased to 8 species, then declined in 2008 when only 6 species were found. In any case, Fishermans Creek seems

Table 10. Number of fish of each species sampled at each site in 1999, 2000, 2001, 2003, 2005, and 2008.

		NT 02					NT 03		NT05					NT 06			
Genus species	**Common name**	1999	2001	2003	2005	2008	1999	2008	2000	2001	2003	2005	2008	1999	2001	2003	2008
Petromyzontidae																	
Lampetra aepyptera	(Least Brook Lamprey)	100	42	43	24	7	1	0	41	24	2	77	2	44	13	60	2
Petromyzon marinus	(Sea Lamprey)	0	0	0	0	0	1	0	0	0	0	0	0	0	0	2	0
Anguillidae																	
Anguilla rostrata	(American eel)	87	36	25	30	21	138	13	11	4	6	7	7	49	22	20	11
Ictaluridae																	
Ameiurus melas	(Black Bullhead)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ameiurus nebulosus	(Brown Bullhead)	0	1	0	3	0	0	0	7	0	0	0	0	0	0	0	0
Noturus gyrinus	(Tadpole Madtom)	18	4	5	0	1	0	16	0	3	1	1	1	7	5	0	0
Noturus insignis	(Margined Madtom)	0	0	1	0	0	0	2	0	0	0	0	1	3	0	2	2
Esocidae																	
Esox niger	(Chain Pickerel)	1	1	1	1	0	0	0	4	3	1	0	0	10	2	0	0
Aphredoderidae																	
Aphredoderus sayanus	(Pirate Perch)	25	6	8	0	7	0	0	10	0	0	1	0	20	2	4	0
Umbridae																	
Umbra pygmaea	(Eastern Mudminnow)	5	9	12	37	6	0	0	15	13	5	1	0	15	13	21	1
Cyprinidae																	
Cyprinella spiloptera	(Spotfin Shiner)	0	0	0	0	0	0	13	0	0	0	0	3	0	0	0	6
Hybognathus regius	(E. Silvery Minnow)	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Luxilus chrysocephalus	(Striped shiner)	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Notemigonus crysoleucas	(Golden Shiner)	0	1	0	5	1	5	1	0	0	0	0	0	0	0	0	0
Notropis amoenus	(Comely Shiner)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Notropis analostanus	(Satinfin shiner)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Notropis chalybaeus	(Ironcolor shiner)	0	0	0	0	0	0	0	0	0	3	0	0	0	0	8	0
Notropis hudsonius	(Spottail Shiner)	2	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0
Notropis procne	(Swallowtail shiner)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rhinicthys atratulus	(Blacknose dace)	0	0	1	0	3	0	0	0	0	0	0	0	0	0	0	0
Notropis bifrenatus	(Bridal shiner)	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Poeciliidae																	
Gambusia holbrooki	(Eastern mosquitofish)	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 10. (continued)

		NT 02					NT 03		NT05					NT 06			
Genus species	**Common name**	1999	2001	2003	2005	2008	1999	2008	2000	2001	2003	2005	2008	1999	2001	2003	2008
Catostomidae																	
Erimyzon oblongus	(Creekchub Sucker)	9	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Moxostoma erythrurum	(Golden Redhorse)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Moxostoma macrolepidotum	(Shorthead redhorse)	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0
Fundulidae																	
Fundulus diaphanus	(Banded killifsh)	1	0	0	0	0	0	0	0	0	0	0	0	75	0	0	0
Fundulus heteroclitus	(Mummichog)	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Percidae																	
Etheostoma flabellare	(fantail darter)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Etheostoma olmstedi	(Tessellated Darter)	78	27	25	27	27	8	9	6	6	1	5	1	75	25	25	16
Perca flavescens	(Yellow perch)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Centrarchidae																	
Enneacanthus gloriosus	(Bluespotted Sunfish)	0	0	0	0	0	1	0	0	0	2	0	0	1	2	0	0
Lepomis auritus	(Redbreast Sunfish)	31	11	9	6	6	72	1	13	9	8	14	5	2	9	8	2
Lepomis cyanellus	(Green sunfish)	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
Lepomis gibbosus	(Pumpkinseed)	0	0	2	0	7	0	0	0	0	1	0	2	1	1	2	0
Lepomis gulosus	(Warmouth)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lepomis macrochirus	(Bluegill)	0	0	8	0	0	9	5	2	0	4	0	12	0	5	5	4
Lepomis punctatus	(spotted sunfish)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Micropterus salmoides	(Largemouth Bass)	0	0	0	0	1	0	1	0	0	0	0	0	0	0	1	0
Pomoxis nigromaculatus	(Black crappie)	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0
Clupeidae																	
Alosa psuedoharengus	(Alewife)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Atherinidae																	
Menidia beryllina	(Inland Silverside)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total		**2371**	**2139**	**2143**	**2138**	**2101**	**2243**	**2071**	**2111**	**2064**	**2038**	**2111**	**2042**	**2301**	**2100**	**2162**	**2052**
Number of species		14	11	13	9	14	10	12	11	9	13	8	10	13	12	14	9

Table 10. (continued)

Genus species	Common name	NT 07 1999	NT 07 2001	NT 07 2008	NT 08 1999	NT 08 2001	NT 08 2008	NT 09 1999	NT 09 2001	NT 09 2008	NT9.5 2001	NT9.5 2008	NT 10 1999	NT 10 2001	NT 10 2003	NT 10 2005	NT 10 2008
Petromyzontidae																	
Lampetra aepyptera	(Least Brook Lamprey)	10	6	1	94	79	1	41	24	7	26	6	15	12	5	4	2
Petromyzon marinus	(Sea Lamprey)	0	3	0	10	0	0	4	0	0	1	0	0	1	0	0	0
Anguillidae																	
Anguilla rostrata	(American eel)	48	20	6	36	24	6	87	26	22	18	3	51	38	41	25	6
Ictaluridae																	
Ameiurus melas	(Black Bullhead)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
Ameiurus nebulosus	(Brown Bullhead)	0	0	0	0	0	0	0	0	0	0	3	0	2	0	0	0
Noturus gyrinus	(Tadpole Madtom)	6	8	0	3	2	0	0	16	4	6	2	5	1	0	0	0
Noturus insignis	(Margined Madtom)	0	0	1	5	3	0	7	4	4	0	1	25	10	15	3	5
Esocidae																	
Esox niger	(Chain Pickerel)	3	2	0	0	1	0	1	0	0	0	0	0	5	0	3	0
Aphredoderidae																	
Aphredoderus sayanus	(Pirate Perch)	4	3	0	4	6	0	9	1	0	5	3	5	3	1	3	4
Umbridae																	
Umbra pygmaea	(Eastern Mudminnow)	2	0	0	3	8	0	6	5	1	7	2	4	2	0	1	0
Cyprinidae																	
Cyprinella spiloptera	(Spotfin Shiner)	0	0	5	0	0	0	0	0	6	0	4	0	0	0	4	0
Hybognathus regius	(Eastern Silvery Minnow)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Luxilus chrysocephalus	(Striped shiner)	0	0	0	0	0	0	0	0	3	0	13	0	0	0	0	0
Notemigonus crysoleucas	(Golden Shiner)	0	3	0	0	0	0	0	0	0	0	8	0	0	0	5	0
Notropis amoenus	(Comely Shiner)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Notropis analostanus	(Satinfin shiner)	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0
Notropis chalybaeus	(Ironcolor shiner)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
Notropis hudsonius	(Spottail Shiner)	0	0	0	24	0	0	25	0	0	0	0	5	0	0	0	0
Notropis procne	(Swallowtail shiner)	0	3	0	1	0	0	0	42	0	5	0	0	1	0	0	0
Rhinicthys atratulus	(Blacknose dace)	0	0	0	0	0	0	0	0	1	5	30	0	0	0	0	0
Notropis bifrenatus	(Bridal shiner)	0	0	0	0	0	0	0	0	11	0	30	0	0	0	0	1
Poeciliidae																	
Gambusia holbrooki	(Eastern mosquitofish)	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0

Table 10. (continued)

		NT 07			NT 08			NT 09			NT9.5		NT 10				
Genus species	**Common name**	1999	2001	2008	1999	2001	2008	1999	2001	2008	2001	2008	1999	2001	2003	2005	2008
Catostomidae																	
Erimyzon oblongus	(Creekchub Sucker)	1	0	0	1	3	0	0	1	0	0	0	4	2	0	0	0
Moxostoma erythrurum	(Golden Redhorse)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Moxostoma macrolepidotum	(Shorthead redhorse)	0	0	1	0	0	0	0	0	2	0	1	0	0	0	0	1
Fundulidae																	
Fundulus diaphanus	(Banded killifsh)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fundulus heteroclitus	(Mummichog)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Percidae																	
Etheostoma flabellare	(fantail darter)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Etheostoma olmstedi	(Tessellated Darter)	15	14	10	84	26	8	125	54	35	23	66	17	0	24	30	0
Perca flavescens	(Yellow perch)	0	0	0	0	0	0	0	2	0	0	0	0	33	0	0	0
Centrarchidae																	
Enneacanthus gloriosus	(Bluespotted Sunfish)	10	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0
Lepomis auritus	(Redbreast Sunfish)	19	5	4	32	26	0	1	31	12	19	7	34	17	18	18	2
Lepomis cyanellus	(Green sunfish)	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0
Lepomis gibbosus	(Pumpkinseed)	0	0	0	0	2	2	0	0	1	0	4	0	0	0	0	0
Lepomis gulosus	(Warmouth)	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lepomis macrochirus	(Bluegill)	0	0	1	0	2	0	0	0	3	6	0	2	3	8	2	1
Lepomis punctatus	(spotted sunfish)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Micropterus salmoides	(Largemouth Bass)	0	0	0	0	1	0	0	3	0	1	0	0	0	0	0	0
Pomoxis nigromaculatus	(Black crappie)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Clupeidae																	
Alosa psuedoharengus	(Alewife)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Atherinidae																	
Menidia beryllina	(Inland Silverside)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total		**2117**	**2069**	**2037**	**2296**	**2184**	**2025**	**2313**	**2210**	**2120**	**2123**	**2199**	**2166**	**2131**	**2119**	**2107**	**2030**
Number of species		11	12	9	13	14	5	13	13	15	13	18	12	15	9	14	9

Table 10. (continued)

		NT 11						NT 12			NT 13					NT14		
Genus species	**Common name**	1999	2000	2001	2003	2005	2008	1999	2001	2008	1999	2000	2001	2003	2008	2000	2001	2008
Petromyzontidae																		
Lampetra aepyptera	(Least Brook Lamprey)	25	30	15	19	49	1	113	86	7	0	58	154	62	10	0	0	0
Petromyzon marinus	(Sea Lamprey)	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Anguillidae																		
Anguilla rostrata	(American eel)	105	37	30	39	30	14	12	20	12	15	31	38	28	17	3	33	22
Ictaluridae																		
Ameiurus melas	(Black Bullhead)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ameiurus nebulosus	(Brown Bullhead)	5	0	0	0	0	0	0	1	0	0	0	1	0	21	0	0	3
Noturus gyrinus	(Tadpole Madtom)	2	2	0	1	0	0	18	1	5	0	0	0	0	0	0	0	0
Noturus insignis	(Margined Madtom)	0	0	0	0	2	0	8	4	2	0	0	0	0	0	0	0	0
Esocidae																		
Esox niger	(Chain Pickerel)	4	6	5	1	2	1	5	3	0	0	1	2	2	2	0	0	0
Aphredoderidae																		
Aphredoderus sayanus	(Pirate Perch)	1	0	4	3	2	0	3	6	0	0	0	0	0	0	0	1	0
Umbridae																		
Umbra pygmaea	(Eastern Mudminnow)	1	0	0	3	2	0	10	11	0	5	5	30	99	2	0	31	1
Cyprinidae																		
Cyprinella spiloptera	(Spotfin Shiner)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hybognathus regius	(Eastern Silvery Minnow)	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Luxilus chrysocephalus	(Striped shiner)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Notemigonus crysoleucas	(Golden Shiner)	5	0	7	0	2	0	0	0	0	0	0	0	2	3	0	2	0
Notropis amoenus	(Comely Shiner)	0	6	0	0	0	2	0	0	2	0	0	0	0	0	0	0	0
Notropis analostanus	(Satinfin shiner)	0	0	0	19	0	0	0	0	0	0	0	0	0	0	0	0	0
Notropis chalybaeus	(Ironcolor shiner)	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Notropis hudsonius	(Spottail Shiner)	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0
Notropis procne	(Swallowtail shiner)	0	0	21	0	0	15	0	0	1	0	0	0	0	0	0	0	0
Rhinicthys atratulus	(Blacknose dace)	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0
Notropis bifrenatus	(Bridal shiner)	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0
Poeciliidae																		
Gambusia holbrooki	(Eastern mosquitofish)	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 10. (continued)

		NT 11						NT 12			NT 13					NT14		
Genus species	**Common name**	1999	2000	2001	2003	2005	2008	1999	2001	2008	1999	2000	2001	2003	2008	2000	2001	2008
Catostomidae																		
Erimyzon oblongus	(Creekchub Sucker)	0	0	9	0	0	0	7	0	0	17	7	13	5	0	0	10	0
Moxostoma erythrurum	(Golden Redhorse)	0	2	0	0	0	0	0	0	0	0	1	0	0	8	0	0	0
Moxostoma macrolepidotum	(Shorthead redhorse)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fundulidae																		
Fundulus diaphanus	(Banded killifsh)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0
Fundulus heteroclitus	(Mummichog)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	150	2	1
Percidae																		
Etheostoma flabellare	(Fantail darter)	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Etheostoma olmstedi	(Tessellated Darter)	17	0	32	16	31	17	24	17	7	0	0	0	0	0	0	0	0
Perca flavescens	(Yellow perch)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Centrarchidae																		
Enneacanthus gloriosus	(Bluespotted Sunfish)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lepomis auritus	(Redbreast Sunfish)	71	15	8	3	8	3	22	6	1	0	0	0	0	0	0	0	0
Lepomis cyanellus	(Green sunfish)	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Lepomis gibbosus	(Pumpkinseed)	8	0	1	2	0	0	0	0	0	29	0	8	3	8	0	11	5
Lepomis gulosus	(Warmouth)	0	0	0	0	0	0	0	0	0	0	11	0	0	0	0	0	0
Lepomis macrochirus	(Bluegill)	10	16	8	2	0	0	0	0	0	0	0	0	0	0	4	0	8
Lepomis punctatus	(spotted sunfish)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Micropterus salmoides	(Largemouth Bass)	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	4	2
Pomoxis nigromaculatus	(Black crappie)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Clupeidae																		
Alosa psuedoharengus	(Alewife)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18	0	0
Atherinidae																		
Menidia beryllina	(Inland Silverside)	0	0	0	0	5	0	0	0	0	0	0	0	0	0	15	0	0
Total		**2259**	**2125**	**2142**	**2111**	**2146**	**2062**	**2221**	**2156**	**2052**	**2065**	**2114**	**2247**	**2205**	**2079**	**2190**	**2098**	2051
Number of species		14	11	13	12	14	9	11	11	11	5	8	8	9	9	6	10	9

Table 11. Comparison of fish collected by SMRP in 2000 or 2001 to MBSS in 2000 at stations in common to both sampling periods.

	NT06		NT08		NT9.5		NT10		NT11			
	2001	2000	2001	2000	2001	2000	2001	2000	2000	2001	2000	
	SMRP	MBSS	SMRP	MBSS	SMRP	MBSS	SMRP	MBSS	SMRP	SMRP	MBSS	Total
American eel	22	1	24	7	18	-	38	2	37	30	23	202
Blacknose dace	-	-	-	-	5	-	-	-	-	-	-	5
Bluegill	5	2	2	9	6	3	3	-	-	-	6	36
Bluespotted sunfish	2	-	-	-	-	-	-	-	16	8	-	26
Brown bullhead	-	-	-	-	-	-	2	-	-	-	8	10
Chain pickerel	2	-	1	5	-	2	5	1	-	-	1	17
Comely shiner	-	-	-		-	-	-	-	6	5	-	11
Creekchub sucker	-	-	3	15	-	2	2	-	6	-	1	29
Eastern mudminnow	13	34	8	145	7	13	2	45	-	9	-	276
Fathead minnow	-	123	-	-	-	-	-	-	-	-	-	123
Golden Shiner	-	5	-	9	-	-	-	-	2	-	2	18
Green sunfish	-	-	-	-	-	-	-	-	-	7	-	7
Ironcolor shiner	-	-	-	27	-	-	-	-	-	-	-	27
Largemouth bass	-	-	1	-	1	-	-	-	-	-	-	2
Least brook lamprey	13	-	79	33	26	66	12	2	1	1	4	237
Margined madtom	5	-	3	0	-	3	10	-	30	15	3	69
Pirate perch	2	-	6	20	5	5	3	-	-	-	2	43
Pumpkinseed	1	1	2	7	-	4	-	-	-	-	-	15
Redbreast sunfish	9	-	26	6	19	35	17	-	-	4	33	149
Satinfin shiner	-	-	-	-	-	-	-	-	-	1	-	1
Sea Lamprey	-	-	-	-	1	4	1	-	15	8	-	29
Spotted sunfish	-	-	-	23	-	-	-	-	-	-	-	23
Swallowtail shiner	-	-	-	-	5	-	1	-	-	-	2	8
Tadpole madtom	-	-	2	-	6	4	1	-	-	-	3	16
Tessellated darter	25	-	26	2	23	50	-	10	-	21	19	176
Warmouth	-	-	-	-	-	-	-	-	2	-	-	2
Yellow perch	-	-	-	-	-	-	33	-	-	32	-	65
Total fish	99	166	183	308	122	191	130	60	125	131	107	

to have low fish diversity overall and this is probably attributable to poor habitat conditions in the station's 75 m sampling segment.

Many stations (NT 06, NT 09, NT 11, and NT12, for example) were consistent in the number of species collected across nearly 10 years (Table 10). In 2008, NT 9.5 had the most species (17) and also had the greatest number of (191) individuals of all sations. When this site was sampled in 2000 by a MBSS survey crew, they found a total of 218 fish in 15 species (Stranko and Rodney, 2001), a strikingly similar finding. Other results sharply contrasted one another. At Jarboesville Run (NT08), for example (Table 11), MBSS collected 308 fish (the largest collection out of 7 sites) in 12 species, but this synoptic survey found only 17 total fish in just 4 species. In addition, when we compared MBSS 2000 results to SMRP 2000 or 2001 results, there was some strong disagreement between the collections as well (Table 11). For example, at the 5 stations that we had in common, there was a huge discrepancy in the number of Eastern mudminnows, a notoriously tolerant species, with 237 found by MBSS and only 30 found by SMRP. Likewise, 123 fathead minnows were found by MBSS at NT06 (Table 11), but SMRP has never collected a fathead minnow.

Yet, there were points of agreement between the MBSS-SMRP samples in more general terms. We agree, for example, that the dominant species are Eastern mudminnow, Least brook lamprey, American eel, and Tessellated darter, but we do not agree that their abundance is in this order. We also agree that Hickory Hills tributary (NT06) has a fish community that is declining in numbers and diversity. And the same is true for Jarboesville Run because 12 and 13 species, respectively, were found in 1999 and 2000 at Jarboesville Run (Table 10), and subsequent sampling (Table 10) revealed that fish diversity was declining seriously at this station. It is probable that urbanization in these two subwatersheds is having a profound impact on the fish in these streams. The discrepancy between MBSS and SMRP fish collections is attributable to professional expertise. It is likely that the field identification of some rare species in SMRP samples (Bridled shiner, Warmouth, and Satin fin shiner) was incorrect because of the inexperience of SMRP field assistants. In addition, it is probable that MBSS and SMRP had different sampling segments with different fish assemblages in each.

In an attempt to further compare our fish results with MBSS data and specifically with Boward et al.'s (1998) fish IBI results, we computed provisional Indices of Biological Integrity (IBI) using Roth et al.'s (1996) method. We did this for fish sampled by SMRP between 1999 and 2005 (Figure 11), but did not compute IBI's for 2008 because the parameters, matrices, and classification of fish were inconsistent between pre-2008 and 2008 data sets.

Despite the inability to compare 2008 data to previous data with IBI's, most of our stations showed very strong agreement between 1999 and 2001 fish collections (Figures 11 and 12). Over all years and all stations, 36 IBI scores were obtained for fish samples between 1999 and 2005 (Table 12, Figure 11). Of these scores, 67% (24) were > 4.0 and classified

as “Good” stations, 28% (10) had mean IBI values between 3.0 and 4.0 and were classified as “Fair” stations, with only 5% (2) with IBI scores <3 (“Poor” stations).
When IBI results were considered on a year-by-year basis, 1999 and 2001 had strikingly similar results, and this was probably due to the fact that 11 of 13 stations were the same in these two years (Figure 12). IBI proportions based on 2001 and 2003 data were also similar, but the number of stations sampled was considerably fewer, 4 and 6, respectively. The IBI proportions shown in Figure 10 for 2005 were based on only 4 stations being sampled in that year.

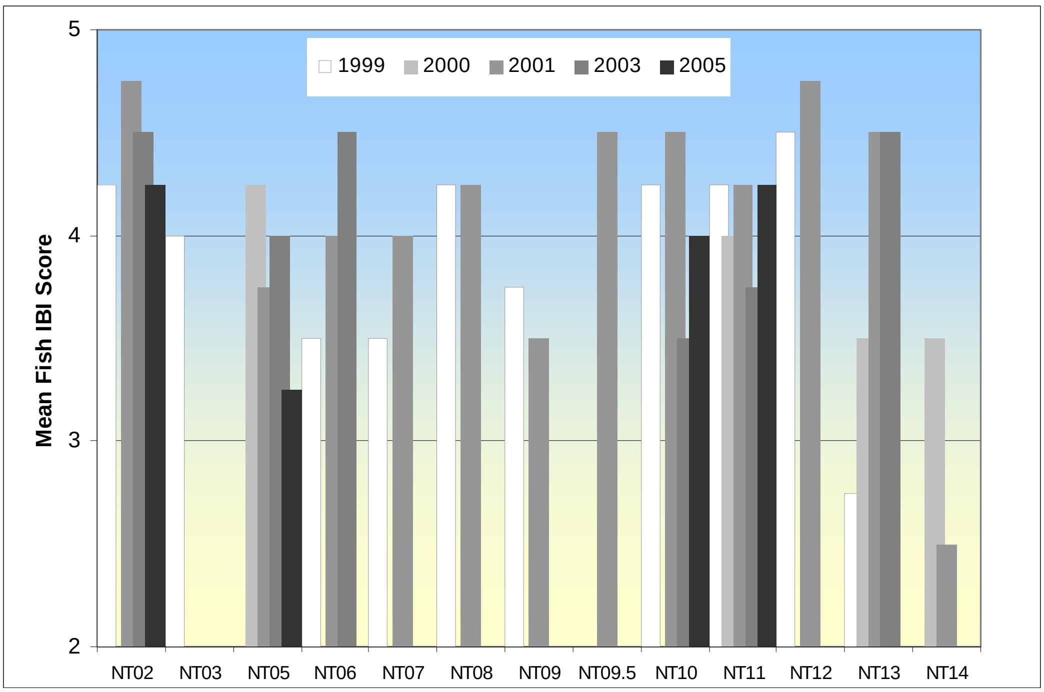

Figure 11. Mean score of Index of Biological Integrity (IBI) for non-tidal fish communities at St. Mary’s River Project stations. Mean scores >4 = good, 4- 3 = fair, <3 = poor (after Roth et al., 1996).

Table 12 and Figures 11 and 13 show IBI scores by station across the span of SMRP sampling years. It is clear that Church Creek (NT14) had the lowest scores, and while this is based on only two sample years, 2000 and 2001, the station has poor habitat and a strong fish community is not supported. The4 site with the highest mean IBI scores and with at least 4 scores was NT02, Warehouse Run. In contrast to Church Creek, Warehouse Run has good in-stream habitat, a high aquatic insect diversity (Table 7), and cold water temperatures year-round. John’s Creek only has a single SMRP score of 4.5 from 2001, but it also has a MBSS score of 4.75 (Table 12), making this stream the highest scoring station for those with less than 4 fish samples. Some other stations with high IBI scores, such as NT11 (Pembrook Run), have fairly high IBI score despite clear signs of habitat degradation. For the most part, year-to-year IBI scores were consistent and did not range greater than one 1.0 IBI score. Therefore, we feel that the conditions at stations, as measured by fish community diversity, are relatively stable and have not changed much since 1999.

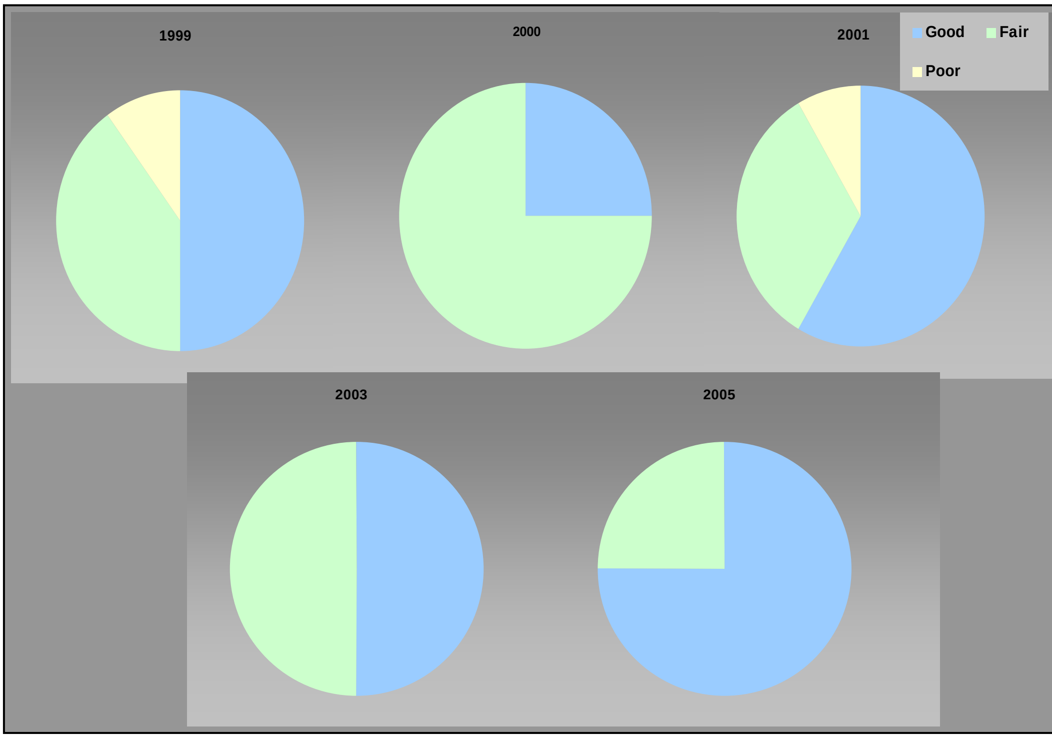

Figure 12. Percentage of fish IBI scores for SMRP samples by year for the period, 1999-2005. Good IBI >4, Fair IBI = 4- 3, Poor IBI <3.

Table 12. Fish IBI scores at each non-tidal station, 1999-2005, and MBSS IBI scores for sites sampled in 2000 (Stranko and Rodney, 2001).

Station Number	Site Name	SMRP IBI's 1999	2000	2001	2003	2005	MBSS IBI's 2000
NT02	Warehouse Run	4.25	-	4.75	4.50	4.25	-
NT03	Below SM Lake	4.00	-	-	-	-	-
NT05	Landfill Trib	-	4.25	3.75	4.00	3.25	-
NT06	Hickory Hills	3.50	-	4.00	4.50	-	2.75
NT07	Norris Road	3.50	-	4.00	-	-	-
NT08	Jarboesville Run	4.25	-	4.25	-	-	3.75
NT09	US Gaging Station	3.75	-	3.50	-	-	-
NT09.5	Johns Creek	-	-	4.50	-	-	4.75
NT10	Hilton Run	4.25	-	4.50	3.50	4.00	3.00
NT11	Pembrook Run	4.25	4.00	4.25	3.75	4.25	4.25
NT12	Eastern Branch	4.50	-	4.75	-	-	-
NT13	Fisherman's Creek	2.75	3.50	4.50	4.50	-	-
NT14	Church Creek	-	3.50	2.50	-	-	-

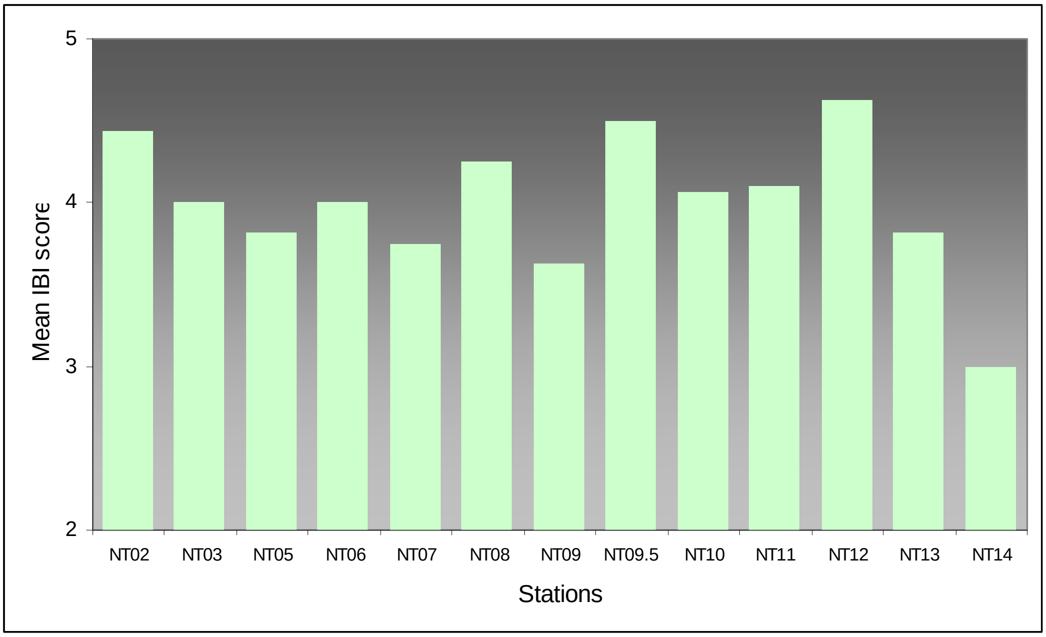

Figure 13. Mean fish IBI scores for all non-tidal stations, 1999-2005.

Discussion and Conclusions

Water quality data collected in this Synoptic Survey parallel the data collected by SMRP during the period from 1999 through 2006 (Paul, 2006) as well as the data compiled by MDE in early 2008. Non-tidal streams in the watershed are thermally stable with relatively low summer maximal temperatures. These low temperatures and no point sources of pollution combine to produce high dissolved oxygen concentrations in all St. Mary's watershed streams sampled. St. Mary's streams are either neutral of slightly acidic because their buffering capacity (alkalinity) is low and this is partially reflected in the streams' consistently low conductivity values. Likewise, nutrients are also relatively low, with some minor exceptions. Nitrogen concentrations (nitrite-nitrate) are usually well below 1.0 mg/L, and phosphorus (orthophosphate) averaged well below 0.005 mg/L.

The exception to these excellent water quality results is Locust Grove Cove (NT01) where water quality was often poor. Although this site is tidally influenced, it has a historical record (Paul 2006) of poor water quality. Some of the nutrient results at this site can be explained by its estuarine characteristics (phytoplankton growth contributing to high particulate carbon, inorganic phosphorus, dissolved organic carbon concentrations), low Secchi disk depths, and general eutrophication. St. George Creek, the receiving water body of Locust Grove Cove, also has water quality problems, and these sites are water bodies have the watershed's worst water quality. The source of these problems is unclear, but this area is the site of the Harry Lundeberg School of Seamanship farm and cattle operation. St. George Creek also has older residential properties (Andover Estates) and other close-to-the-water properties, where septic systems prevail, and these may be failing.

It should be mentioned that non-tidal water quality assessment in this synoptic survey was only taken on two days, July 10th and 11th, when conditions were dry and had been for sometime. There is good reason to believe (Paul, 2006) that the watershed's water quality problems are driven by storm events. These promote erosion, which carry sediments and nutrients into the streams and eventually into the estuarine waters. However, since our sampling did not include storm events, this scenario is somewhat speculative and based on observation rather than a body of collected evidence. Yet, tidal samples collected during May and June storm events show a pattern of tidal response to storms, and this was particularly true for salinity, algae, turbidity, and dissolved oxygen.

For the most part, tidal water quality at the mid-point in the St. Mary's River estuary (St. Mary's College dock) was also good. Dissolved oxygen was near saturation across most dates and at most depths, with the exceptions of two dates (May 14th and June 11th). Secchi disk depths were below 1 m for the entire study, again with the exception of the storm-driven events in June. An algal bloom early in the study, April 30th, drove chlorophyll levels above 20 ug/L, but this seemed like an isolated, not very severe incident.

Our biological results also support our historical data and reflect the water quality conditions documented in this study. Macroinvertebrate survey data and our analysis of aquatic insects provide a biological appraisal of conditions in 2008. However, because these surveys were done very early in the study period at only 9 stations, and only 6 of these could be compared to previous studies, the assessment is rather limited. When these data are taken together with historic SMRP data from 1999 to 2006, however, a general picture of relatively strong biological heath emerges. In-stream aquatic habitat for insects is generally good in the watershed, and stream insect communities reflect this health. But some subwatersheds and their streams which have their headwaters in the Lexington Park Development District are showing signs of impact. There were some surprising anomalies encountered in 2008 compared to other years and these are difficult to explain. Historically, the Landfill Tributary (NT 02) has had poor insect diversity but the reverse was true in 2008, and conversely Warehouse Run has had excellent insect diversity sionce 1999, but poor results in 2008. These confusing results could be better understood with repeated spring sampling at these stations in the future.

Four subwatersheds, in particular, seem to be impacted the most as evaluated by aquatic insect diversity: NT06- Hickory Hills Tributary, NT08- Jarboesville Run, NT11 Pembrooke Run, and NT14 – Church Creek. The first three sites have their headwaters in the development district, and it is fairly clear from stream channel morphology and imbeddedness that the bottom habitat of these streams has been altered by sedimentation. It is likely that up-stream erosion is the culprit and this is probably promoted by impervious surface development and poor storm water management practices. Church Creek has been long know to have difficulties because of poor storm water management off Route 5 in the vicinity of Villa Road. The State Highway Administration has attempted to rectify this problem with a storm water catchment but it is probably ineffectual.

Fish samples taken in 2008 were supportive of the fish and macroivertebrate conclusions from previous years at three stations in particular, NT06- Hickory Hills, NT08- Jarboesville Road, and NT14- Church Creek. But some additional stations sampled for fish in 2008, point to problems at NT07- Norris Road, and NT10- Hilton Run. Norris Road has rather poor fish habitat, but Hilton Run is something of a surprise because many (4) previous samples at this station showed pretty good fish diversity as measured by IBI.

In conclusion, the results of the synoptic survey tend to support the idea that the tidal creeks of the St. Mary's River have poorer water quality that the open main stem of the river. Storm events seem to be the dominant perturbation force in the river, bring nutrients and sediments into the tidal main stem, from as far away as the development district. Yet, the impacts of sediment generation through erosion seem to be more localized near their points of production. The main impact here is habitat degradation affecting the biological resources of the streams. In the tidal river, nutrients and sediments fuel algal production, which diminishes light passage through the water column, and lowers dissolved oxygen content of the water as the algae die, sink, and decompose.

Literature Cited

Boward, D, D. Randle, P. Kazyak, H. Dail, and J. Christmas. 1998. Lower Potomac River Basin, Environmental Assessment of Stream Conditions. (CBWP-MANTA-EA-96-5). Chesapeake Bay and Watershed Programs, Maryland Department of Natural Resources, Annapolis, Maryland.

Jessup, B.K., A. Markowitz, and J.B. Stribling. 2002. Family-level Key to the Stream Invertebrates of Maryland and Surrounding Areas. CBWP-MANTA-EA-99-2, Chesapeake Bay and Watershed Programs, Maryland Department of Natural Resources, Annapolis, Maryland.

Kazyak, P.F. 1997. Maryland Biological Stream Survey. Sampling Manual Monitoring and Non-Tidal Assessment. Chesapeake Bay and Watershed Programs, Maryland Department of Natural Resources, Annapolis, Maryland.

Kazyak, P.F., R.L. Raesly, and D.A. Neely. 2003. A provisional key to the freshwater fishes of Maryland. Chesapeake Bay and Watershed Programs, Maryland Department of Natural Resources, Annapolis, Maryland.

KCI. 1998. Watershed Evaluation for St. Mary's River and McIntosh Run Watersheds. (01-98022B). Prepared for the St. Mary's County Department of Planning and Zoning. KCI Technologies, Inc., Hunt Valley, Maryland.

Page, L.M. and B.M. Burr. 1991. A Field Guide to Freshwater Fishes. Houghton Mifflin Company, Boston, Massachusetts.

Paul, R.W. 2006. Riverlands-Translating St. Mary's River Water Quality Data into Public Policy, Final Report submitted to Environmental Protection Agency, Chesapeake Bay Program, November, 2006.

Paul, R.W. and C.E. Tanner. 2001. Final Report YR1. Grant #: X-983090-01 to Mary's College of Maryland. Delivered to the Environmental Protection Agency, Region III, Philadelphia, PA, submitted February 2001.

Paul, R.W. and C.E. Tanner. 2005. Final Performance Report, St. Mary's River Project. U.S. Department of Housing and Economic Development, EDI-Special Project number B-01-SP-MD-0780, submitted July 7, 2005.

Peckarsky, B.L., P.R. Fraissnet, M.A. Penton, and D.J. Conklin. 1990. Freshwater Macroinvertebrates of the Northeastern North America. Cornell University Press, Ithaca, New York.

Plafkin, J.L., M.T., Barbour, K.D. Porter, S.K. Gross, and R.M. Hughes. 1989. Rapid Bioassessment Protocols for Use in Streams and Rivers—Benthic Macroinvertebrates and Fish. U.S. Environmental Protection Agency (EPA/440/4-89/001). Washington, D.C.

Roth, N.E., M.T. Southerland, J.C. Chaillou, J.H. Volstad, S.B. Weisberg, H.T. Wilson, D.G. Heimbuch, and J.C. Seibel. 1996. Maryland biological stream survey: Ecological status of non-tidal streams in six basins sampled in 1995. Draft report. Versar, Inc. Columbia, Maryland.

Stranko, S. and W. Rodney. 2001. Final Data Report: Habitat Quality and Biological Integrity Assessment of Freshwater Streams in the Saint Mary's River Watershed. CBWP-MANTA-EA-01-2. Chesapeake Bay and Watershed Programs, Maryland Department of Natural Resources, Annapolis, Maryland.

Acknowledgements

Without the hard work of the survey crew this Synoptic Survey would never have been possible. The crew members were Megan Hession, Rebecca Wright, Lauren Smith, Andrew Keppel, and Katie Zdilla from St. Mary's College of Maryland. Also, special thanks to Travis Mattingly from Leonardtown High School.