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Impacts of Acid Deposition on Fish Populations in St. Marys River, Augusta County, Virginia

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INTRODUCTION

Acid deposition, which includes rain, drizzle, fog, sleet, snow and dry particulate matter, has been impacting aquatic ecosystems in the mid-Atlantic and southeastern United States for at least the past two decades (Herlihy et al., 1993: Webb et al., 1994). Pre-industrial pH of precipitation in Virginia has been estimated to be from 5.3 to 5.6 (Webb, 1987). By 1996, precipitation pH readings at the Big Meadows water monitoring station in Shenandoah National Park, Madison County, Virginia averaged 4.4 (U.S. Environmental Protection Agency, 1998). This represents a tenfold increase in precipitation acidity since the beginning of the 20th century.

Acid deposition alone is not necessarily harmful to aquatic life. A watershed's ability to buffer acid precipitation determines whether the system suffers long-term biological degradation. Acid neutralizing capacity (ANC) is the ability of water to successfully neutralize additional acid ions. Desirable ANC levels for freestone headwater streams should be greater than 100 ueq/L (Webb, 1987). Once the finite ANC is completely exhausted, a stream no longer has the capability to neutralize incoming sources of acid and pH will decline. Under chronically acidic conditions, acid intolerant species are lost, leaving a less diverse community composed largely of acid tolerant species. Intense, bottom up alterations of food webs often occur in waters with acidic pH levels. (Hendrey, 1982). Increased mobilization of heavy metals such as aluminum, mercury, and lead from stream sediments has been documented in acidified waters (Baker, 1982). These metals, particularly aluminum, have been found to induce gas transfer complications in fish gills that can lead to asphyxiation (Leivestad, 1982). Reproductive development in fish can also be impaired in acidic environments (Peterson et al., 1982).

In 1987, a synoptic study of the water chemistry of 350 of Virginia's 450 wild trout streams, known as the Virginia Trout Stream Sensitivity Study (VTSSS), was conducted by the Virginia Department of Game and Inland Fisheries (VDGIF) in association with the University of Virginia's Department of Environmental Sciences. The result of that investigation indicated that over 78% of the sampled waters had ANC values <100 ueq/L (Webb, 1987). Of these "acid sensitive" streams, 11% were considered to be acidic (mean ANC values of zero or less). St. Marys River, once a premier wild trout fishery, was one of the watersheds in Virginia that fell into the acidified category.

Historic pH measurements recorded in St. Marys River through 1976 were consistently above 6.5 (Table 1). The one to two unit decline in mean pH levels during the eleven year gap between the last Department of Game and Inland Fisheries' pH test in 1976 and the beginning of the Virginia Trout Stream Sensitivity Study in 1987 clearly indicates that St. Marys River has become acidified.

St. Marys River has a long history of commercial, scientific, and recreational interest. In the 1910s, the Pulaski Iron Company built a railroad spur up the St. Marys River gorge to Chimney Branch (Fig. 1). The railroad served to transport manganiferous iron ore from excavated surface mines in the watershed to the Norfolk & Western Railroad siding at Pkin (Stose et al., 1919). The operation was abandoned after World War I but resumed briefly during World War II. Environmental damage to St. Marys River and some of its tributaries during the height of the mining operation was noted by the local populace but the watershed began to recover by 1935, when "a few nice trout" were noted in the pools of the main stream (Surber, 1951).

Scientists began examining the fauna of the St. Marys River watershed with the studies of Eugene Surber in the 1930s. In October 1936, Surber started a two-year investigation of water chemistry, stream flow, invertebrate

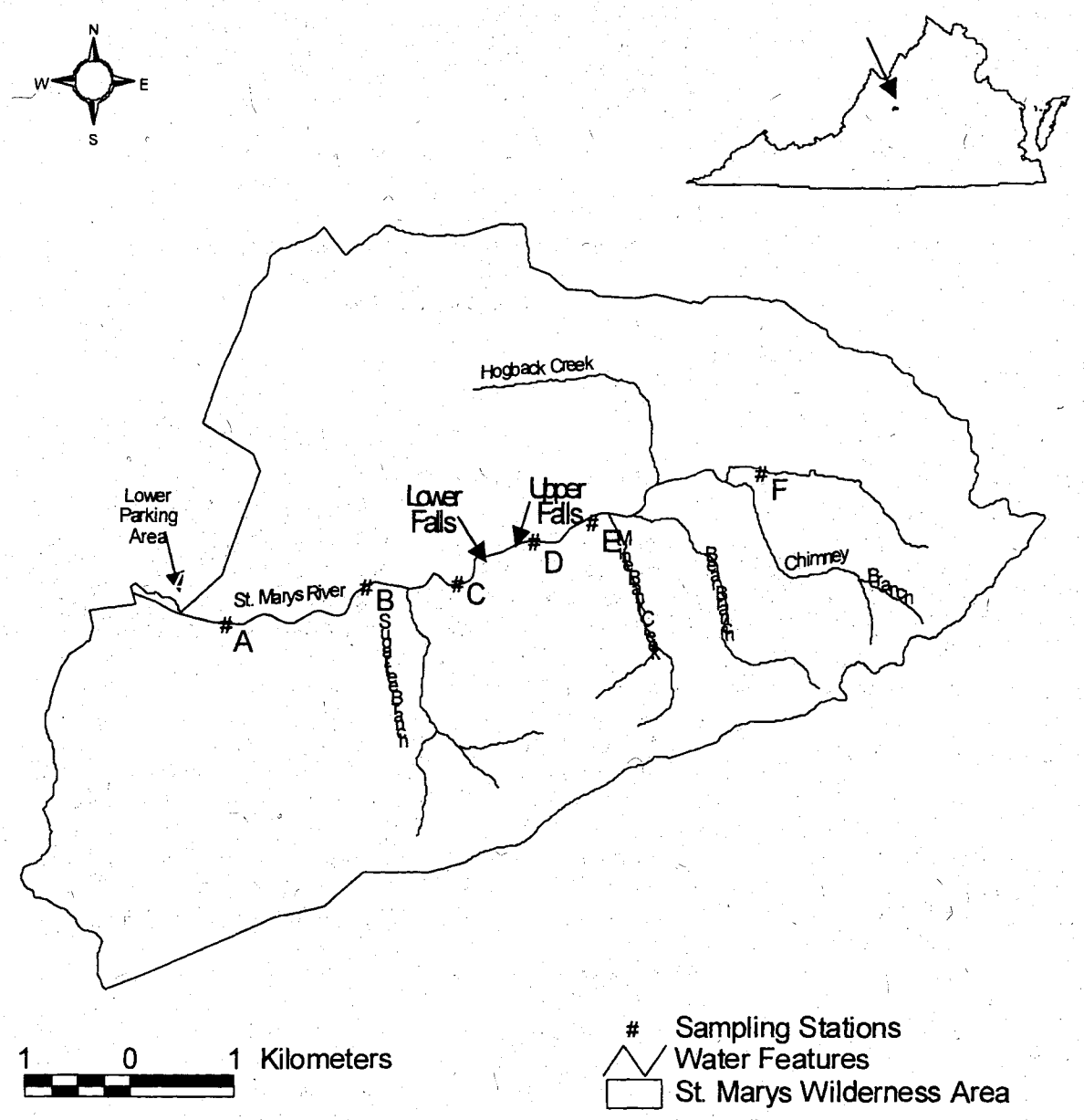


Fig. 1. Virginia Department of Game and Inland Fisheries sampling stations in the St. Marys River watershed, Augusta County, Virginia.

populations, and trout bioenergetics in St. Marys River (Surber, 1951). His study provided invaluable baseline data for future scientific endeavors. Although Surber closely examined water quality and macroinvertebrate populations, he did not sample fish populations in the watershed. Examination of angler catches generated the data for his bioenergetics work on trout. Chemical and flow information were collected in 1973 and 1974 by Trout Unlimited, and a creel survey was undertaken by Trout Unlimited in 1975 in order to quantify angler pressure and harvest on St. Marys River trout populations (G.D. Schuder, unpublished letter to VDGIF, 1976). As a result of these studies and other observations, St. Marys River became one of Virginia's earliest special regulation trout streams.

The Virginia Department of Game and Inland Fisheries' management activities in St. Marys River have ranged from the stocking of catchable trout to monitoring

Table 1. Historic and recent pH values for St. Marys River.

Year	Season	pH
1938	Summer	6.90
1938	Fall	6.70
1939	Spring	6.80
1973	Fall	7.00
1974	Spring	7.00
1974	Summer	6.90
1974	Fall	6.70
1976	Summer	6.80*
1976	Summer	7.00
1989	Winter	5.07*
1989	Winter	5.72
1989	Summer	5.15*
1989	Summer	5.69
1997	Winter	5.48
1997	Spring	5.68

*collected in upper watershed
1938-1939: pH was determined by unknown methods
1973-1976: pH was determined by Hach Model 17N colorimeter
1989-1997: pH determined electronically with Beckman Psi 21 pH meter

chemical and biological changes in the watershed. VDGIF stocked adult rainbow (*Oncorhynchus mykiss*) and brook trout (*Salvelinus fontinalis*) in St. Marys River from 1948 until 1974. This practice was discontinued due to severe access road damage caused by Hurricanes Camille and Agnes. In 1976 VDGIF staff conducted a comprehensive physical, chemical, and biological survey of the watershed as part of its statewide trout stream inventory project (Mohn & Bugas, 1980). These electrofishing surveys provided the earliest complete fisheries community study. Because the results of the 1976 investigation did not generate any immediate concern for more intensive work in the watershed, scientific investigation of the St. Marys River system was not pursued again by VDGIF until 1986. At that time the river was noted to be acidic, so VDGIF began biennial surveys of the fish and benthic communities (Kauffman et al., 1999). The United States Forest Service's (USFS) Coldwater Fisheries Research Unit from Virginia Tech conducted basinwide snorkel and electrofishing surveys in St. Marys River and the tributaries Mine Bank Creek, Chimney Branch, and Hogback Creek in 1989, 1994, and 1997 (P.A. Flebbe, personal communication). These surveys estimated total fish population size and determined fish distribution throughout the watershed by using visual quantification techniques.

In this paper, we have examined changes in the distribution, abundance, and density of fish species in St. Marys River over a 22 year period. The disturbing decline of fish in this watershed that are sensitive to low pH follows a similar pattern to other waterbodies that are exposed to acidic precipitation over long periods of time.

STUDY AREA

St. Marys River is a third order coldwater stream that drains the west slope of the central Blue Ridge Mountains in southeastern Augusta County, Virginia. It forms the southwest boundary of the Big Levels Management Area and its 27 km^2 watershed is the centerpiece of the 4,000 hectare St. Marys Wilderness Area. St. Marys River originates at 951 m above sea level and descends at a gradient of 39 m/km to its confluence with Spy Run, 11.4 km downstream. The watershed is comprised of five

Table 2. Electrofishing stations in the St. Marys River watershed, Augusta County, Virginia.

Station	Elevation (m)	Stream km from Wilderness boundary	Sample length (m)	Sample area (ha)
A	524	0.35	171	0.12
B	570	2.61	123	0.08
C	610	3.97	127	0.10
D	646	5.11	76	0.04
E	661	5.98	161	0.07
F	722	8.13	91	0.02

Table 3. Fish distribution in St. Marys River by sample year and sample station. Letter denotes uppermost station in the watershed where individual species were collected.

Fish Species	1976	1986	1988	1990	1992	1994	1996	1998
Brook Trout	F	F	F	F	F	F	F	F
Blacknose Dace	E	E	E	C	A	B	A	A
Fantail Darter	C	C	C	C	C	B	B	B
Mottled Sculpin	B	B	B	B	B	B	B	B
Rosyside Dace	B	B	B	B	A	B	A	
Torrent Sucker	C	B	B	B	B		A	
Rainbow Trout	E	E	C	C	C			
Longnose Dace	B	A			A			
Johnny Darter	A					A		
White Sucker	B	A						
Bluehead Chub	A			A				
Central Stoneroller		A						
Smallmouth Bass			B					
Brown Trout	C					A		
Total Species	12	10	8	8	8	7	6	4

major tributaries (Fig. 1). St. Marys River's low ANC levels can be traced to the geologic formations that underlie the watershed. Antietam quartzite is the primary rock formation (Werner, 1966). Formations of Hampton quartzite underlie the upper watersheds of Sugartree Branch, Mine Bank Creek, Bear Branch, and Chimney Branch, as well as the lower reach of St. Marys River. Both formations are known to have low solubility in water, thus providing few reactive materials to neutralize acidic input (Downey, 1994).

Dominant overstory vegetation in the St. Marys River basin include chestnut oak (*Quercus prinus*) and scarlet oak (*Quercus coccinea*) on ridges and north aspects, with pitch pine (*Pinus rigida*) and table mountain pine (*Pinus pungens*) dominating the southern and western slopes. Understory plants include mountain laurel (*Kalmia latifolia*), bear oak (*Quercus ilicifolia*), rhododendron (*Rhododendron maximum*), flowering dogwood (*Cornus florida*), red maple (*Acer rubrum*), and black gum (*Nyssa sylvatica*). Well drained, sandy loam covers most of the watershed, with the primary soil type being Drall-Hazleton-Leetonia. (Hockman et al., 1979). It is considered to be poor, acidic soil (Downey, 1994).

MATERIALS AND METHODS

In June 1976, VDGIF selected St. Marys River as one of 35 coldwater streams to be intensively studied as part of the Virginia Trout Stream and Environmental Inventory (Mohn & Bugas, 1980). Fisheries surveys were again conducted during late June of 1977, 1986, 1988, 1990, 1992, 1994, 1996, and 1998. Six sample stations were selected on St. Marys River from the lower Wilderness Area boundary to the headwaters (Fig 1.,Table 2). These sites were distributed throughout the mainstem starting from the Wilderness Area boundary and extending to the headwaters. Stations ranged from 76 to 171 m in length and included at least three sets of riffle, runs, and pools. Block nets (0.95 mm mesh) were set across the stream channel at the lower end of the station, while small waterfalls constituted the upper end of a site. A four person crew completed three electrofishing passes. All fish species encountered during each pass were netted and retained in individual holding pens by run. In 1976, fisheries work was completed with a shore-based 5 amp, 230 volt DC generator. This system was replaced with homemade battery powered backpack electrofishing units in the 1980s and from 1990 to present Smith-Root Model 12 battery powered backpack units have been used. After collected fish were sorted and counted by species, non-game fish were weighed in aggregate by species and released. All trout were measured to the nearest millimeter (mm), weighed to the nearest gram (gm), and released back into the stream. Population estimates were determined using the Maximum Weighted Likelihood Method with Microfish 3.0 software (Van Deventer & Platts, 1986). Stream width was measured at each station to calculate areas sampled.

Table 4. Biomass estimates in kg/ha for six fish species in St. Marys River, Augusta County, Virginia, 1976-1998.

	Year							
Species/Station	1976	1986	1988	1990	1992	1994	1996	1998
Brook trout								
A	0.8	3.4	3.2	10.1	15.3	6.4	5.4	9.0
B	9.3	10.7	18.7	19.0	16.1	10.4	7.6	25.1
C	6.4	6.0	9.4	19.6	9.9	15.7	3.0	20.1
D	0.7	1.2	0.6	21.3	26.6	2.4	8.1	57.3
E	6.3	6.2	4.3	16.0	26.2	10.3	17.7	19.7
F	27.2	10.7	1.1	16.5	8.4	2.1	5.9	1.1
Blacknose dace								
A	1.0	1.6	2.0	1.0	4.5	0.5	0.2	0.1
B	3.7	1.2	1.4	0.7	0.0	0.2	0.0	0.0
C	0.4	0.0	0.0	0.1	0.0	0.0	0.0	0.0
D	2.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
E	1.4	0.1	0.1	0.0	0.0	0.0	0.0	0.0
F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fantail darter								
A	0.3	1.0	0.1	0.3	0.4	0.5	0.1	0.1
B	1.7	0.1	0.7	0.1	0.0	0.0	0.0	0.0
C	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0
D	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
E	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mottled sculpin								
A	0.8	1.2	2.2	11.9	1.6	1.3	0.4	0.4
B	0.1	1.3	8.7	0.7	0.1	5.7	0.3	0.1
C	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
D	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
E	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rosyside dace								
A	0.1	0.1	0.6	1.2	0.7	0.0	0.2	0.0
B	3.8	0.5	0.8	3.5	0.0	0.1	0.0	0.0
C	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
D	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
E	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Torrent sucker								
A	2.1	1.2	2.9	4.1	10.9	0.0	0.1	0.0
B	5.7	3.6	2.9	3.4	0.0	0.0	0.0	0.0
C	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
D	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
E	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rainbow trout								
A	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
B	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C	1.3	0.0	7.7	1.7	2.7	0.0	0.0	0.0
D	16.1	3.9	0.0	0.0	0.0	0.0	0.0	0.0
E	4.4	4.5	0.0	0.0	0.0	0.0	0.0	0.0
F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

RESULTS

Fish Distribution

Fourteen fish species have been collected from St. Marys River and its major tributaries since 1976 (Table 3). Brook trout, blacknose dace *(Rhinichthys atratulus)*, mottled sculpin *(Cottus bairdi)*, and fantail darter *(Etheostoma flabellare)* have been collected in all eight VDGIF surveys (Table 3). Rosyside dace *(Clinostomus funduloides)* were present in all of the surveys through 1996. Rainbow trout and torrent sucker *(Moxostoma rhothoecum)* were frequently encountered in their historic ranges through 1992. Since 1992, no rainbow trout have been collected in the St. Marys River watershed and only a single torrent sucker was captured in 1996. Fish species less frequently encountered include longnose dace *(Rhinichthys cataractae)*, brown trout *(Salmo trutta)*,white sucker *(Catostomus commersoni)*, bluehead chub *(Nocomis leptocephalus)*, central stoneroller *(Campostma anomalum)*, johnny darter *(Ethostoma nigrum)*, and smallmouth bass *(Micropterus dolomieui)* (Table 3).

Brook trout have been the most widely distributed fish species in the stream and have historically been collected at all six VDGIF sample stations (Table 3). Blacknose dace, a common coldwater stream cyprinid, was commonly found as far upstream as Station E through 1988, but its local distribution has been reduced to the lower reaches of the watershed in recent years. Distribution of fantail darters and torrent suckers have similarly been reduced to lower sample stations (Table 3). Mottled sculpins maintained their historic distribution patterns at sites A and B since 1976. Rosyside dace were frequently collected at Stations A and B over time, but were not found in the 1998 surveys.

Between Sugartree Branch and Mine Bank Creek, the gradient in St. Marys River increases to 43m/km and is

Table 5. Density estimates in number/km for three fish species in St. Marys River, Augusta County, Virginia, 1976-1998.

	Year							
Species/Station	1976	1986	1988	1990	1992	1994	1996	1998
Brook trout								
A	18	146	211	263	327	310	88	327
B	195	285	309	415	252	528	89	764
C	543	189	299	425	220	362	47	528
D	26	26	303	382	276	105	53	961
E	193	130	665	205	416	236	112	453
F	593	143	66	165	88	22	33	11
Blacknose dace								
A	164	427	719	298	1105	129	29	12
B	813	301	325	171	0	41	0	0
C	94	0	0	16	0	0	0	0
D	447	0	0	0	0	0	0	0
E	137	6	12	0	0	0	0	0
F	0	0	0	0	0	0	0	0
Rainbow trout								
A	0	0	0	0	0	0	0	0
B	0	0	0	0	0	0	0	0
C	110	0	94	31	24	0	0	0
D	289	92	0	0	0	0	0	0
E	75	37	0	0	0	0	0	0
F	0	0	0	0	0	0	0	0

characterized by numerous large waterfalls and deep plunge pools. It was in this reach that rainbow trout, a naturalized holdover from early stocking programs, remained in St. Marys River through 1992. Rainbow trout were found at Stations C, D, and E in 1976, Stations C and D in 1988, and only at Station C in 1990. Rainbow trout have not been collected in the last three VDGIF electrofishing surveys.

The remaining fish species were less frequently collected; their abundance was low, and distributions were generally limited to the lower stations (Table 3). Smallmouth bass are considered to be an occasional transient in the lower reaches. Brown trout, another stocking holdover, were collected as far upstream as Station C in 1976, but their range has been reduced to the deep pool habitat of Station A. Like the rainbow trout, brown trout have naturalized in St. Marys River and appear to prefer the lower reaches of the watershed. Brown trout were relatively abundant in 1976 and in 1977 but only one has since been collected (in 1994).

Fish Abundance

The fish community in St. Marys River has changed dramatically since 1976 (Table 4). Brook trout is the dominant predatory species and the only indigenous salmonid in St. Marys River. In 1976, it was well distributed throughout St. Marys River and its major tributaries. Brook trout biomass ranged from 0.6 kg/ha at Station D in 1988 to 57.3 kg/ha at Station D in 1998 (Table 4).

Rainbow trout were moderately abundant at Stations C, D, and E in 1976 but have not been seen since 1992. A total of seven brown trout were collected at Stations A, B, and C in 1976 and four were found in 1977 at stations A and B during a partial survey of the river. Brown trout were last collected from the watershed in 1994. Blacknose dace biomass declined precipitously over the duration of the study (Table 4). This species was common in 1976 up to Station E (1.4 kg/ha). By 1986, only a few individuals were collected in the watershed above Sugartree Branch. Blacknose dace were abundant at Station A (4.5 kg/ha) in 1992 and relatively abundant at Station B (0.7 kg/ha) through 1990, however, a total of only five individuals were collected at Station A and none at Station B in both 1996 and 1998. Mottled sculpin have been fairly abundant at Stations A and B, but biomass has notably declined at both of these sites since 1994 (Table 4). Fantail darters historically populated St. Marys River in moderate numbers up to Station C. Station B has not produced a fantail darter since 1990 and Station C yielded a single specimen in 1992. Except for a single specimen found in 1996, torrent suckers have not been seen since 1992. Rosyside dace was a common component of the fish community at Station A through 1992 and at Station B through 1990. However, only one specimen was collected in 1994, four were collected in 1996, and none were found in 1998.

Brook trout numbers remained stable from 1988 through 1994, but dropped considerably in 1996 (Table 5). The population rebounded to a historic high in 1998 but most of the population consisted of a single year class (100-150 mm) spawned during the dry winter of 1996 (Fig. 2). Station A is currently the only sample site where blacknose dace are regularly collected. Blacknose dace densities reached an historic level of 1,105 fish/km in 1992, but declined to 12 fish/km in 1998. Table 5 shows that this species was abundantly distributed in the watershed to Station E in 1976, but populations have since declined dramatically in number and range. Rainbow trout numbers were strong at Stations C, D, and E in 1976 (Table 5), but 10 years later densities dropped critically. The rainbow trout were last collected at Stations D and E in 1986, and at Station C in 1992.

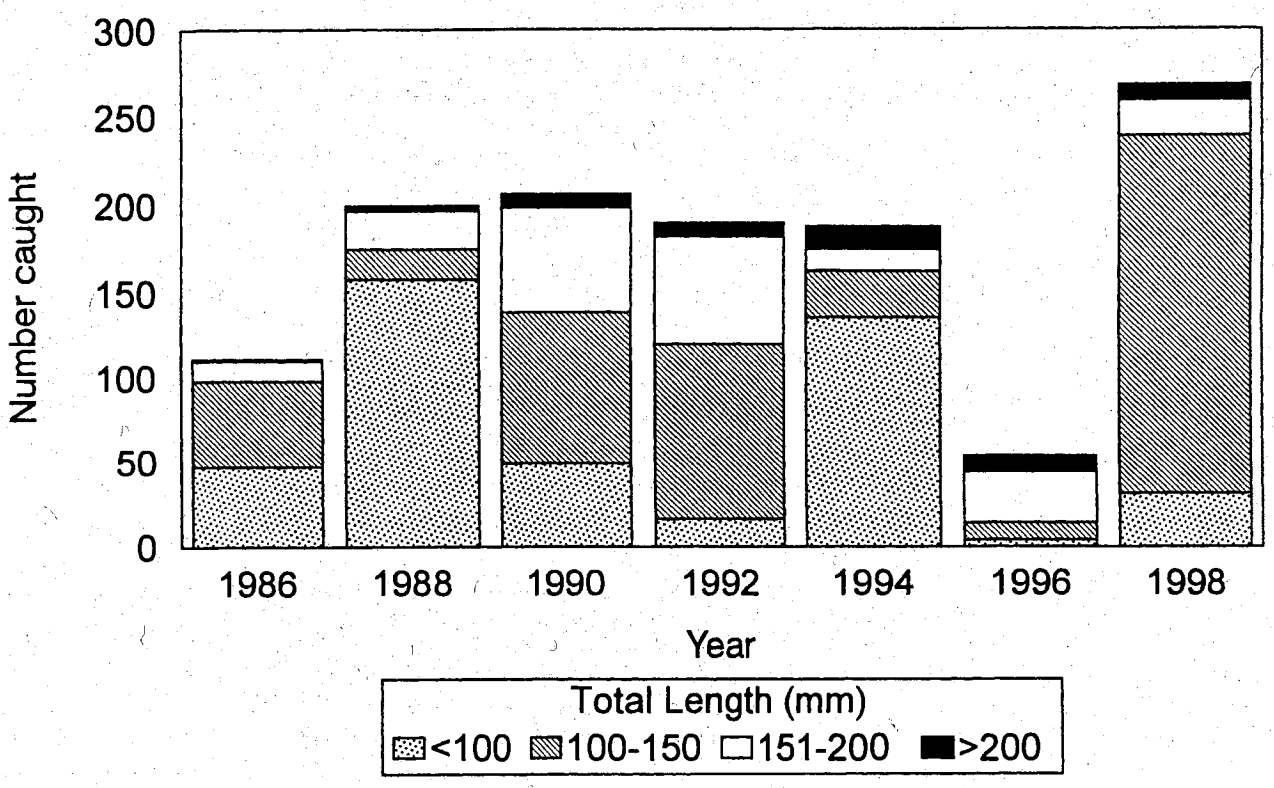
DISCUSSION

Fish abundance, species diversity, and distribution patterns in St. Marys Rivers have been dramatically altered since 1976. In 1998, VDGIF monitoring produced only four fish species: brook trout, blacknose dace, fantail darter, and mottled sculpin, a loss of two-thirds of the 12 fish species collected in 1976. Seven fish species were consistently represented in the 1976-1992 surveys (Table 3), but of those, rainbow trout have subsequently disappeared from our samples and only one torrent sucker has been collected (in 1996). Rosyside dace, historically another common species of both Station A or B, was not found in 1998. Brown trout were frequently encountered up to Station C in 1976 and were found in a qualitative VDGIF survey in 1977, but both their numbers and distribution have been reduced over time. In 1994, a single brown trout was found at Station A, possibly indicating a small, remnant population still existing in the lower watershed.

Brook trout are the most acid tolerant of all fish species that reside in St. Marys River, but populations begin to decline when pH consistently remains at 5.0 or lower (Schneider, 1986). Despite current acidic conditions, they remain distributed throughout St. Marys River.

Rainbow trout and blacknose dace are two among the most acid sensitive fish species in the watershed. Population loss begins to occur at a pH of 6.0 for both species (Magnuson, 1983; Schofield & Driscoll, 1987). Rainbow trout have not been collected since 1992 and are assumed to be gone from the system (Table 4, 5). Blacknose dace were historically found in moderate densities up to Mine

Fig. 2. Composition of biennial samples of brook trout by size classes in St. Marys River, Augusta County, Virginia, 1986-1998. Samples represent total number of individuals in all stations combined.



Bank Creek. Today, blacknose dace distribution is limited to Station A (and in some unnamed tributaries) where pH and ANC levels are somewhat higher than in the upper watershed. Blacknose dace density at Station A has also declined dramatically since 1992. During their 1989 and 1994 snorkel surveys, USFS researchers found blacknose dace distributed between Sugartree Branch and Mine Bank Creek, but none was found in their 1997 survey (P.A. Flebbe, personal communication). These researchers calculated that basinwide blacknose dace abundance dropped from 182 individuals in 1989, to 18 in 1994, and to zero in 1997. Mottled sculpin abundance and distribution in St. Marys River has remained relatively unchanged since 1976. Mottled sculpins are moderately sensitive to decreasing pH levels (Rahel & Magnuson, 1983). Recruitment failure in the slimy sculpin (*Cottus cognatus*), a species that requires similar environmental conditions as the mottled sculpin, begins in waters with a pH between 5.3 and 5.8 (Magnuson, 1983). Information about acid sensitivity of the remaining St. Marys River fish species is lacking. The extirpation of rainbow trout, coupled with sharp declines in blacknose dace and other non game fish populations, is symptomatic of aquatic environments that are poorly buffered against the effects of acid precipitation.

Brook trout spawn in the fall and eggs or sac fry remain in redds for up to four months (Jenkins & Burkhead, 1994). During this period, nests are frequently exposed to episodic flushes of acidic water. In acidified waters, a wet winter and early spring often result in poor egg or fry survival and increased natural mortality. Such was the case in St. Marys River during the winters of 1994/95, 1995/96 and 1997/98. Low survival from 1994/95 and 1995/96 year classes resulted in a small 1996 population of brook trout (Fig. 2). Young-of-the-year brook trout were abundant in 1994 (Fig. 2) and contributed to a strong spawning population (>150 mm) during fall of 1996. This large spawning population, combined with low flows throughout the winter of 1996/97 resulted in an abundance of young-of-the-year brook trout (D. Kirk, personal communication) in the St. Marys watershed in 1997. These fish survived to form a significant component of the 1998 survey and are represented in Fig. 2 as 100-150 mm fish (1+ year old). Although the brook trout in the St. Marys River watershed are currently abundant, successful reproduction has occurred only once in the past

four years due to an unusually low flow fall and winter that minimized episodic acidic pulses.

From 1976 to 1998, the number of fish species in St. Marys River declined from 12 to 4. Of the species remaining, densities of some species are severely reduced and brook trout reproduction appears to be sporadic. Historic fish distribution patterns within the watershed for all species, except brook trout, have been altered during the survey period. This study shows that a twenty two year decline in the fish community of St. Marys River has occurred as a result of anthropogenic acid deposition. Although the brook trout population appears to be less affected by acidification than the other species, it remains vulnerable due to the interaction of life history, flow regimes, and acidification.

To forestall further water quality degradation in St. Marys River, the U. S. Forest Service has proposed to add approximately 140 tons of limestone sand to the five major tributaries and in St. Marys River near Station F (D. Kirk, personal communication). The goal of this action will be to artificially raise pH to a mean level of 6.5 (A. Christensen, USFS Environmental Assessment, 1998). With improved water quality, St. Marys River should temporarily provide a environment suitable for re-establishment of its indigenous aquatic organisms, as well as improve the brook trout population to a level where the river will reclaim its reputation as one of Virginia's premier trout fisheries.

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