EVALUATION OF SMALLMOUTH BASS YEAR CLASS STRENGTH AND POPULATION SIZE AT THREE NORTHERN INDIANA RIVERS

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Smallmouth bass are historically the dominant predator and most sought after game fish in northern Indiana rivers. Their numbers are thought to have declined in some rivers due to one or a combination of factors: physical habitat degradation, water quality deterioration (both point and non-point source pollution), and possibly angler overharvest.

In 1989, a one year fishery project was initiated with the following objectives:

1) Determine smallmouth bass population size at two stations on the Elkhart, Pigeon, and St. Joseph Rivers and correlate with catch per unit effort (CPUE).

2) Determine smallmouth bass year class strength at two stations on the Elkhart, Pigeon, and St. Joseph Rivers and relate to seasonal variations in water temperature and stream discharge (flooding and drought).

3). Evaluate the Pigeon River smallmouth bass stockings at the Rock Dam (PI2) station and impacts of the 12 inch minimum size limit at the Rock Dam (PI2) and Ontario (PI6) stations.

4) Quantify the fish community structure at two stations on the Elkhart, Pigeon, and St. Joseph Rivers.

DESCRIPTION OF RIVERS

The three rivers evaluated were the Elkhart, Pigeon, and St. Joseph (Figure 1). The St. Joseph was the largest with an average discharge of 3,176 cubic feet per second (cfs) and drainage area of 3,370 square miles at Elkhart, Indiana. The Elkhart had an average discharge of 514 cfs and drainage area of 594 square miles at Goshen, Indiana while Pigeon was the smallest river evaluated with an average discharge of 369 cfs and drainage area of 361 square miles at Scott, Indiana. Both the Elkhart River and Pigeon Rivers are tributaries of the St. Joseph River which drains into Lake Michigan in southwest Michigan.

Two stations were sampled on each of the three rivers. Specific locations of each station are presented in Appendix A. River stations are abbreviated in the text and tables. Abbreviations consist of the first two letters of the appropriate river followed by the number of the station. The furthest upstream station at each river was assigned the number 1. The six stations sampled retained their station abbreviations from previous work conducted between 1986 and 1988 (Stefanavage 1987, 1988, and 1989)

METHODS

Smallmouth and Rock Bass Evaluations

Only smallmouth and rock bass were collected by boat-mounted dc electrofishing during most one hour collection periods between May 15 and September 27, 1989. An effort was made to collect all fish observed while electrofishing the weeks of May 21and July 23.

The length of each fish collected was measured to the nearest 0.1 inch except for species such as common shiner and other small Cyprinids in which more than twenty individuals were collected. In this case, twenty randomly selected individuals were measured and bulk weighed. Smallmouth and rock bass were not weighed since length/weight equations were available, for each river, from previously collected data. Weights were recorded to the nearest 0.1 pound on five individuals per one-half inch group for other species collected. Scale samples, were taken from ten individuals per one-half inch group for game fish only.

Bass population size was estimated using Schnabel multiple mark and recapture methods. Standing stock was determined by multiplying the predicted weight of bass per one-half inch group by the estimated number of bass per length interval.

During the first sampling period, all bass collected were marked by punching a hole in the upper lobe of the caudal fin. This was considered the first marking run. During subsequent periods, bass were checked for marks, marked if not already marked, and measured.

Stations were sampled between eight and nine times. Limited night sampling was conducted in order to evaluate the effectiveness of collecting smallmouth at night and to increase sample size.

The size structure of each station's smallmouth population was described on the basis of proportional stock density (PSD) and relative stock density of twelve inch fish (RSD-12). Anderson and Weithman (1978) defined PSD for smallmouth bass as the number of quality size fish (≥ eleven inches) divided by the number of stock size fish (≥ seven inches). RSD-12 was defined as the number of twelve inch and longer fish divided by the number of stock size fish. Recaptured fish were not included in length frequency distributions or in PSD and RSD-12 determination.

Water Quality

Dissolved oxygen, total alkalinity, and pH were measured with a Hach portable water test kit. Conductivity and temperature were measured with a YSI model 33 S-C-T meter while water clarity was measured with a secchi disk. These data were measured usually after each electrofishing collection.

RESULTS

SMALLMOUTH AND ROCK BASS EVALUATIONS

Fifty-one, one hour electrofishing collections at the six stations sampled resulted in a catch of 4,277 smallmouth bass (Appendix B). Smallmouth catch per unit effort (CPUE), which was defined as the number caught per one hour electrofishing, averaged 83.9 and ranged from 4 to 249 (Appendix C). Mean CPUE varied from 12.1 at PI2 to 147.2 at ST3 (Table 1).

Night collections during midsummer resulted in catches two to three times higher than midsummer daytime collections (Appendix C). The largest catches occurred during midspring and early fall when water temperatures were below 68°.

Table 1. Smallmouth bass mean CPUE by station, 1989.

STATION	YOY	Age 1	Age 2	Age 3 & Older	Total
EL6	0.3	18.9	57.9	15.6	92.6
EL7	0.2	18.0	40.2	10.3	68.8
PI2	0.1			12.0	12.1
PI6	0.3	18.5	30.1	6.0	54.9
ST2	3.0	33.7	66.4	14.2	117.3
ST3	5.3	12.4	110.9	18.6	147.2
Mean	1.5	20.3	61.1	12.8	82.2

The catch of age 1+ bass generally increased over time as these fish grew in size and became more vulnerable to electrofishing. Young-of-the-year bass were first collected August 14 and their catch increased over time as they grew in size and became more vulnerable to electrofishing.

Smallmouth PSD's ranged from 51 at PI2 to 11 at ST2 (Appendix B). Pigeon and Elkhart River stations generally had higher PSD's than St. Joseph River stations (36 and 31 versus 13). RSD-12's which ranged from 29 at PI2 to 8 at ST2 were also generally higher for Pigeon and Elkhart stations (21 and 22 versus 9).

Young of the year (YOY) bass were most common at the two St. Joseph station comprising 3.2 and 4.1% of the total number of smallmouth collected (Table 2). YOY were not as abundant at

the other rivers where they only comprised 0.3 to 1.7%. Elkhart and St. Joseph River stations with higher YOY catches in 1988 had higher age 1+ catches in 1989.

Table 2. Smallmouth bass population age structure by station, 1989.

	PERCENT COLLECTED PER AGE GROUP				NUMBER*
STATION	0+	1+	2+	3+ & Older	COLLECTED
EL6	0.3	19.8	62.7	17.3	597
EL7	0.4	27.1	56.7	15.9	510
PI2	1.7			98.3	60
PI6	0.6	36.2	52.9	10.3	312
ST2	3.2	30.2	54.9	11.7	847
ST3	4.1	8.5	75.2	12.1	1,163

* excludes recaptures.

In all, 795 smallmouth bass were aged. Smallmouth bass growth at the Elkhart River stations continued to be slower than at St. Joseph stations (Table 3). Pigeon River bass growth was intermediate to the other two streams.

Table 3. Smallmouth bass back calculated lengths at annulus formation per station using an intercept of 1.4 inches, 1989.

	LENGTH (inches)						NUMBER
STATION	1+	2+	3+	4+	5+	6+	AGED
EL6	3.8	6.4	8.6	10.6	11.8		123
EL7	3.7	6.2	8.7	10.5	11.7	13.1	134
PI2	3.4	5.9	8.2	10.2	12.2	13.7	39
PI6	3.8	6.7	9.5	11.6	13.6	15.5	142
ST2	3.7	6.9	9.2	10.6	11.8		198
ST3	4.3	7.2	10.3	12.1			159

Density estimates of age I and older smallmouth bass were calculated for all stations (Table 4). Additional, separate estimates were calculated for age 1, age 2, age 3 and older, and bass ≥ 12.0 inches in length.

Table 4. Smallmouth bass number/acre estimates (± two standard errors) by station, 1989.

Station	Age 1+	Age 2+	Age 3+ & Older	SMB ≥ 12.0 inches	Age 1+ & Older
EL6	56 ± 24	150 ± 32	47 ± 20	15 ± 10	256 ± 47
EL7	92 ± 43	116 ± 27	44 ± 25	28 ± 18	246 ± 49
PI2			15 ± 5	4 ± 2	15 ± 5
PI6	35 ± 14	35 ± 8	6 ± 3	3 ± 2	71 ± 14
ST2	87 ± 29	88 ± 15	19 ± 7	4 ± 3	180 ± 26
ST3	32 ± 21	234 ± 43	31 ± 13	9 ± 6	304 ± 50

Pounds per acre by station was also estimated for each of the five age or size groupings (Table 5).

Table 5. Smallmouth bass pounds/acre estimates (± two standard errors) by station, 1989.

Station	Age 1+	Age 2+	Age 3+ & Older	SMB ≥ 12.0 inches	Age 1+ & Older
EL6	2.5 ± 1.1	22.2 ± 4.7	36.4 ± 15.5	17.2 ± 11.5	58.7 ± 10.8
EL7	4.3 ± 2.0	19.0 ± 4.4	45.5 ± 25.8	34.9 ± 22.4	65.3 ± 13.0
PI2			10.6 ± 3.5	4.3 ± 2.1	10.6 ± 3.5
PI6	2.0 ± 0.8	6.8 ± 1.6	6.1 ± 3.0	3.8 ± 2.5	15.6 ± 3.1
ST2	4.3 ± 1.5	14.5 ± 2.5	12.3 ± 4.5	4.9 ± 3.7	33.7 ± 4.9
ST3	2.0 ± 1.3	34.9 ± 6.4	23.8 ± 10.0	12.6 ± 8.4	67.1 ± 11.0

Twenty-two of the thirty calculated estimates had standard errors below the desired 25% level (Table 6). Most of the standard errors >25% came from estimates of age 3+ and older fish, and bass ≥ 12.0 inches.

Table 6. Percent standard error of smallmouth bass population estimates by station, 1989.

Station	Age 1+	Age 2+	Age 3+ & Older	SMB ≥ 12.0 inches	Age 1+ & Older
EL6	21.8	10.8	21.4	33.3	8.7
EL7	23.6	11.8	27.8	31.9	9.9
PI2			16.9	22.7	16.9
PI6	19.6	11.8	25.5	28.0	9.5
ST2	16.5	8.7	18.6	33.3	7.1
ST3	31.7	9.2	20.5	31.8	8.2

The twelve hours of relative abundance sampling (two hours per station) resulted in a catch of forty-nine fish species. Species diversity ranged from a high of 30 species at PI6 to a low of 23 at EL6, EL7, and ST3. The 6,568 individual fish collected (Table 7) weighed 3,429.9 pounds (Table 8). Greater numbers of fish were collected at the Elkhart River stations, due primarily to the abundance of common shiners. The fewest number of fish were collected at PI2. Half of this station was channelized. Smallmouth bass were most abundant by number at

Table 7. Percent relative abundance by **number** of fishes collected by station, 1989.

SPECIES	EL6	EL7	P12	P15	ST2	ST3	GRAND TOTAL
Common shiner	41.3	30.3	14.8	12.3	13.8	0.2	21.1
Smallmouth bass	10.6	14.0	3.9	6.4	19.8	33.7	15.2
Golden redhorse	13.5	10.3	2.8	12.7	13.1	12.7	11.6
Shorthead redhorse	0.3	0.1		25.7	18.3	27.3	11.6
Northern hog sucker	4.8	6.7	14.1	15.8	11.1	6.7	9.1
Hornyhead chub	10.3	17.2	6.6	1.6			6.7
White sucker	5.0	8.2	26.1	2.8		0.7	5.5
Rock bass	8.0	5.7	0.9	5.9	1.6	1.6	4.6
Bluegill	0.5	0.2	2.3	0.7	10.0	3.5	2.6
Carp			4.5	4.9	0.2	1.7	1.5
Pumpkinseed	0.2	1.3	3.8		1.4	5.7	1.8
Green sunfish	0.4	0.1	6.6	0.7	0.5	0.6	0.9
Bluntnose minnow	0.1	0.7	1.5	3.9			0.9
Chestnut lamprey	0.7	1.7		1.1			0.7
Largemouth bass	1.1	1.5	0.6		0.2		0.6
Channel catfish				0.3	3.1	0.2	0.6
Spotted sucker	0.8	0.3		0.1	0.5	1.3	0.5
Steelcolor shiner	1.1			1.1	0.3		0.5
Quillback					1.4	1.0	0.4
Emerald shiner		0.7		0.8	0.6		0.4
Longear sunfish	0.5				0.9	0.7	0.4
Blackside darter		0.3	3.4				0.3
Logperch		0.1		0.5	1.1	0.3	0.3
Creek chub	0.1	0.4	1.5				0.2
Yellow bullhead	0.2	0.1	0.8	0.4	0.2		0.2
Black crappie	0.1		0.4	0.6	0.2	0.2	0.2
Walleye				0.1	0.2	0.9	0.2
Silver redhorse				0.2	0.4	0.4	0.2
Grass pickeral	0.1		1.3				0.1
White crappie					0.6	0.2	0.1
Bowfin	0.1		0.4	0.4			0.1
Sand shiner				0.6	0.1		0.1
Warmouth		0.1	0.8				0.1
Lake chubsucker			1.1				0.1
Brook silverside			0.6		0.3		0.1
Stonecat			0.4	0.2			0.1
Golden shiner						0.4	0.1
Black bullhead			0.6			0.1	0.1
Blacknose dace	0.1						*
Mottled sculpin			0.4				*
Longnose gar				0.1	0.1		*
Redear sunfish					0.2		*
Spotfin shiner		0.1					*
Northern pike				0.1			*
Iowa Darter				0.1			*
Rosyface shiner				0.1			*
Spottail shiner						0.1	*
Johnny darter		0.1					*
Orangethroat darter				0.1			*
TOTAL # SPECIES	23	23	25	30	27	23	49
TOTAL # FISH	1,489	1,358	532	1,084	1,055	1,050	6,568

Table 8. Percent relative abundance by **weight** of fishes collected by station,1989.

SPECIES	EL6	EL7	P12	P15	ST2	ST3	TOTAL
Shorthead redhorse	3.1	0.2		29.8	49.7	43.8	29.9
Golden redhorse	31.3	27.8	6.9	12.2	23.3	23.7	20.1
Carp			56.8	38.4	1.2	9.9	18.4
Northern hog sucker	8.8	12.9	8.4	8.1	7.9	5.9	7.9
Smallmouth bass	13.5	18.6	4.8	2.3	6.7	8.3	7.4
White sucker	12.7	14.9	15.4	2.0		1.1	4.7
Common shiner	9.8	8.0	1.2	0.9	1.9	*	2.3
Rock bass	8.4	6.8	0.3	1.6	0.6	0.5	2.0
Silver redhorse				0.5	2.3	1.9	1.1
Hornyhead chub	4.8	5.3	0.6	0.2			1.0
Spotted sucker	3.8	1.5		*	0.5	1.0	0.9
Quillback					2.3	1.2	0.8
Bowfin	0.1		2.3	1.4			0.6
Channel catfish				0.5	1.5	0.5	0.6
Walleye				0.4	0.2	1.2	0.5
Largemouth bass	2.1	2.2	0.3		0.1		0.4
Bluegill	0.2	0.1	0.2	0.2	0.9	0.2	0.3
Pumpkinseed	0.1	0.6	0.3		0.2	0.4	0.2
Green sunfish	0.2	0.1	1.1	*	0.1	0.1	0.2
Northern pike				0.6			0.1
Longnose gar				0.4	0.2		0.1
Yellow bullhead	0.4	0.1	0.3	0.1	0.1		0.1
Black crappie	0.3		0.1	0.1	*	*	0.1
Chestnut lamprey	0.2	0.6		*			0.1
Longear sunfish	0.2				0.1	0.1	0.1
Creek chub	*	0.2	0.2				*
White crappie					0.1	*	*
Bluntnose minnow	*	0.1	*	0.1			*
Black bullhead			0.2			*	*
Grass pickeral	*		0.2				*
Golden shiner						0.1	*
Warmouth		0.1	0.1				*
Lake chubsucker			0.2				*
Stonecat			0.1	*			*
Steelclor shiner	0.1			*	*		*
Blackside darter		*	0.1				*
Emerald shiner		*		*	*		*
Logperch		*		*	*	*	*
Redear sunfish					*		*
Sand shiner				*	*		*
Blacknose dace	*						*
Spotfin shiner		*					*
Mottled sculpin			*				*
Brook silverside			*		*		*
Iowa Darter				*			*
Rosyface shiner				*			*
Spottail shiner						*	*
Johnny darter		*					*
Orangethroat darter				*			*
TOTAL # SPECIES	23	23	25	30	27	23	49
TOTAL WEIGHT	302.7	282.3	337.3	871.6	667.0	969.0	3429.9

St. Joseph stations and least abundant at Pigeon River stations. Rock bass were most common at Elkhart stations.

Fish biomass was highest at ST3 and PI6 due to the occurrence of more redhorse or carp. The opposite was true for Elkhart stations which had the lowest biomass, absence of carp, and lower abundance of redhorse. Smallmouth and rock bass, percent relative abundance by weight, was highest at Elkhart stations.

DISCUSSION

Smallmouth bass catch per unit effort (CPUE) was examined by simple correlation analysis (Pearson's r) against estimated bass density (number per acre) and estimated bass standing stock (pounds per acre) (Table 9). PI2 data were excluded since all collected fish were stocked.

The only results meeting the project's criteria for success of $-0.75 < r > 0.75$ were those determined for age 2+ bass. However, earlier results (Stefanavage 1989) utilizing a larger data set (24 points versus 5) already met this criteria for success ($r = 0.88$, significant at the $P<0.01$ level).

Table 9. Correlation coefficient (Pearson's r) calculated for paired variable sets.

	Smallmouth bass			
	Age 1+	Age 2+	Age 3+& Older	Total Population
Density	0.63	0.88	0.50	0.65
Standing Stock	0.66	0.87	0.26	0.45

Smallmouth bass 1989 YOY and age 1+ results for PI6, EL6, and EL7 were then combined with data from previous years for these stations and examined by simple correlation analysis (Pearson's r) against mean spawning season river discharge (April, May, and June monthly discharge was summed and divided by three). Pigeon River YOY smallmouth versus discharge resulted in $r = -0.72$; Pigeon age 1+ ($r = -0.80$), Elkhart YOY ($r = -0.67$), and Elkhart age 1+ ($r = -0.83$). Resulting correlation coefficient's for YOY did not meet the criteria for success ($-0.75 < r > 0.75$) while age 1+ results did.

The collection of a YOY smallmouth bass at PI2 documented that the stocked bass finally reproduced. However, all other bass collected there were age 4+, 5+, and 6+ fish from the 1983, 1984, and 1985 stockings. It was discouraging that no age 1+ or 2+ bass were collected, since there were enough mature bass present in 1987 and 1988 to reproduce. It is still unknown

whether the stocked bass will ever perpetuate themselves. The stocked smallmouth do provide angling opportunities although their growth rate continues to be poor.

Pigeon River smallmouth bass growth rates were similar following implementation of a twelve inch minimum size limit in September 1984. In fact, 1989 bass growth at PI6 was superior to that observed in 1988 (Ledet 1989) and 1986 (Stefanavage 1987).

Bass numbers declined from 1986 through 1989 at PI2, probably due to natural morality or legal harvest of bass greater than twelve inches in length. However, 1989 estimated standing stock (10.6 pounds/acre) was similar to that estimated in 1986 (13.0 pounds/acre).

Conversely, bass numbers in terms of CPUE have drastically increased at PI6 (CPUE of 55 in 1989 versus 19 in 1986, 21 in 1985, and 12 in 1984). Whether this increase is due to the size limit or the production of strong year classes in 1986, 1987, and 1988, is unknown. Smallmouth bass standing stock was also higher at PI6 in 1989 than 1986 (15.6 versus 13.4 pounds/acre) although the 1989 level is still below the record 1985 level of 24.3 pounds/acre.

Smallmouth bass PSD's and RSD'12's for PI2 and PI6 were highly variable 1984 through 1989 (Table 10). PI2 1984 and 1985 results were due to the presence of a single 19.1 inch, native bass in 1984, and a single 19.2 inch smallmouth in 1985. By 1986, some of the stocked bass had reached 11.0 inches and by 1988, some bass had achieved the length of 12.0 inches. Results from 1989 reflect the large proportion of bass ≥ 11.0 and ≥ 12.0 inches, as well as the absence of age 2+ and age 3+ bass.

Native bass population structure at PI6 was highly variable and intermediate to those calculated for the Elkhart and St. Joseph Rivers. These results indicate that the size limit had no impact on Pigeon River bass population size structure. The size structure variability was probably due to annual variations in recruitment and mortality.

Table 10. PSD's and RSD-12's of smallmouth bass collected from two Pigeon River stations, 1984 through 1989.

	PI2		PI6	
	PSD	RSD-12	PSD	RSD-12
1984	100	100	30	24
1985	5	5	21	12
1986	4	0	42	25
1988	11	5	20	10
1989	51	29	20	13

In conclusion, statistical testing indicated a positive, although not significant relationship, exists between smallmouth bass CPUE, density, and standing stock. Statistical testing also indicated a negative, but not a significant, relationship between smallmouth bass

year class strength and high river discharge during the spawning season. A long term project over ten or more years would probably have to be conducted in order to better document relationships between year class strength and annual weather conditions.

Results of the Pigeon River smallmouth bass stockings were positive in terms of providing limited bass fishing in the stocked area. Overall, the stockings were unsuccessful since the stocked fish have yet to perpetuate themselves by producing a year class and it is doubtful if they will in the future.

Implementation of the smallmouth bass minimum size limit at Pigeon River has had no positive or negative effects.

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