STATE OF MICHIGAN
DEPARTMENT OF NATURAL RESOURCES

FR16 February 2017

Sport Fishing Catch and Effort and an Economic Analysis of the Lower St. Joseph River Fishery

Brian J. Gunderman

www.michigan.gov/dnr/

FISHERIES DIVISION
FISHERIES REPORT 16

Suggested Citation Format

Gunderman, B. J. 2017. Sport fishing catch and effort and an economic analysis of the lower St. Joseph River fishery. Michigan Department of Natural Resources, Fisheries Report 16, Lansing.

For information or assistance on this publication, contact:

MICHIGAN DEPARTMENT OF NATURAL RESOURCES,
Fisheries Division
PO BOX 30446
LANSING, MI 48909
517-373-1280

TTY/TDD: 711 (Michigan Relay Center)

This information is available in alternative formats.

Michigan Department of Natural Resources
Fisheries Report 16, 2017

Sport Fishing Catch and Effort and an Economic Analysis of the Lower St. Joseph River Fishery

Brian J. Gunderman

Michigan Department of Natural Resources, Southern Lake Michigan Management Unit, 621 N. 10th Street, Plainwell, Michigan 49080

Abstract.–During 1974–1991, five fish ladders were constructed at hydroelectric dams on the lower St. Joseph River as part of an unusual state-federal interstate project to test fishway designs in the Midwest and allow upstream movement of potamodromous salmonids from Lake Michigan to the Twin Branch Dam. Large-scale stocking programs for Rainbow Trout, Chinook and Coho Salmon, Brown Trout, and Walleye were established to enhance fishing opportunities in this system, which was impaired and fragmented by a series of privately owned dams. To evaluate returns from this substantial investment, Michigan Department of Natural Resources and Indiana Department of Natural Resources conducted creel surveys at eight sites on the lower St. Joseph and Dowagiac rivers during 1985–2006. Fishing effort estimates from these surveys were used to calculate annual economic benefits for the fisheries in Michigan and Indiana. The mean annual fishing effort for all creel survey sites (combined) was 335,219 angler hours during 1999–2004. Approximately two-thirds of the fishing effort occurred in Michigan, but the distribution of fishing effort varied seasonally. Sixty-two percent of the total fishing effort was directed toward salmonids and 11% was directed toward Walleye. Rainbow Trout was the most abundant species in the catch. From 1993 through 2004, only 19% of the steelhead catch (harvest plus release) occurred during the summer, and the summer steelhead fishery was concentrated in the Michigan portion of the river. Chinook Salmon, Coho Salmon, and Brown Trout composed 10% of the total harvest. Bluegill, Walleye, Channel Catfish, and Smallmouth Bass also were notable components of the fishery. Steelhead and Coho Salmon catch rates in the St. Joseph River were similar to or greater than those recorded for the fisheries in the Manistee and Muskegon rivers. Harvest rates for Walleye and catch rates for Smallmouth Bass were average for Michigan waters. Due to continued impairment and fragmentation by private dams and insufficient numbers of fishways at each dam in this test watershed, the economic analysis unsurprisingly indicated that while the St. Joseph River fishery yielded net annual economic benefits in both Michigan and Indiana, it will take many years to recoup the initial capital investments for fish ladder and hatchery construction unless full passage mitigation is provided by the private dam owners. The steelhead fishery in the lower St. Joseph and Dowagiac rivers may be enhanced by stocking Michigan-strain fish instead of Skamania-strain steelhead.

Introduction

The St. Joseph River basin (Figure 1), located in southwest Michigan and north-central Indiana, is the third largest river basin in Michigan. The river begins at Baw Beese Lake in Hillsdale County and flows in a northerly arc before turning south and entering Indiana. The river flows west through the cities of Elkhart and Mishawaka, then makes an abrupt turn to the north at the city of South Bend. The river re-enters Michigan in southeastern Berrien County and flows northwest until it reaches Lake Michigan at the twin cities of St. Joseph and Benton Harbor. The St. Joseph River mainstem is 210 miles long, and its tributaries total an additional 1,641 miles (Wesley and Duffy 1999). The watershed encompasses 4,685 square miles: 3,000 square miles in Michigan and 1,685 square miles in Indiana. The average daily discharge at the mouth is 4,598 cubic feet per second (Dexter and Ledet 1994).

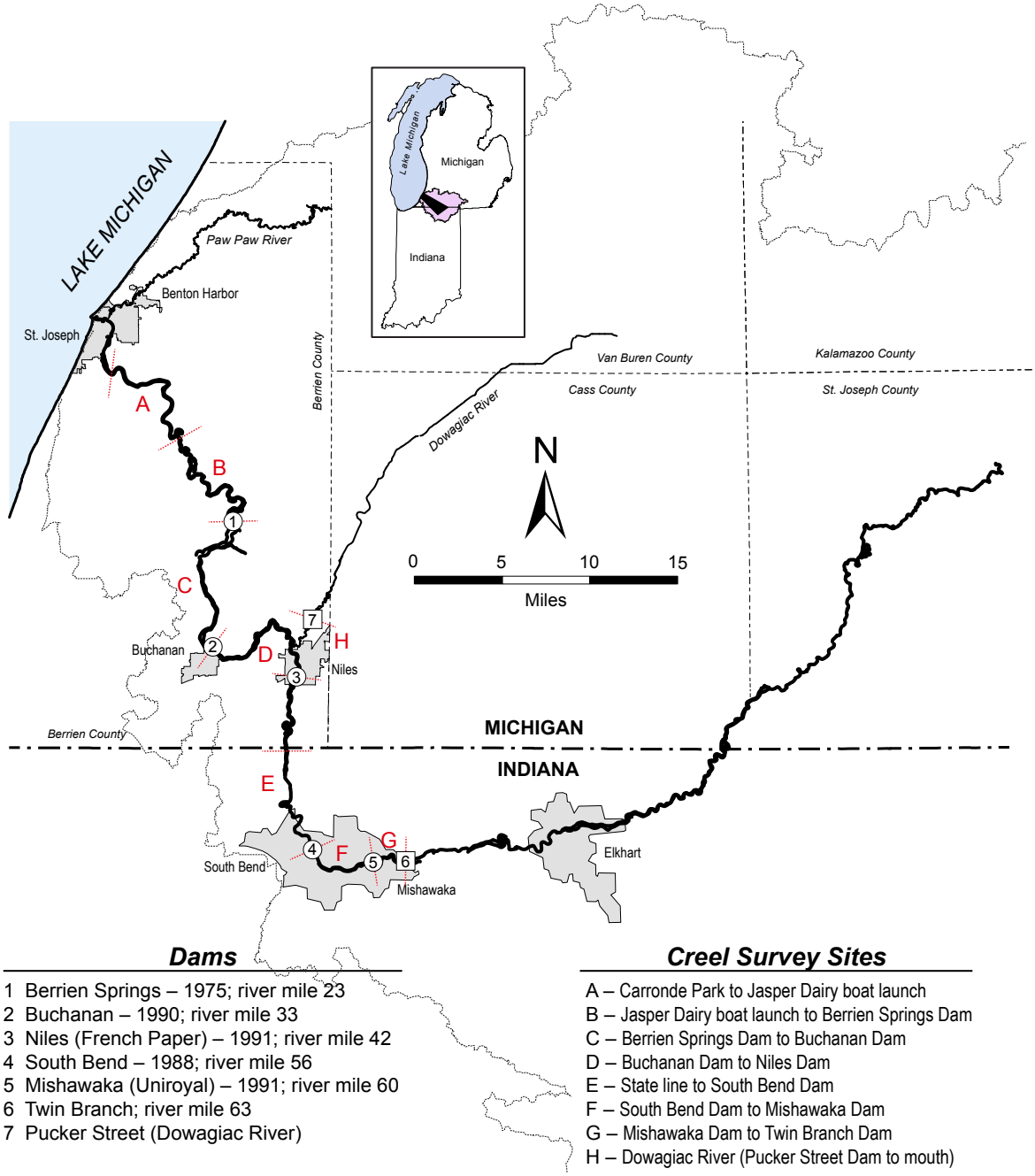


Figure 1.– Major dams and cities in the lower St. Joseph River watershed and creel survey sites on the St. Joseph and Dowagiac rivers, 1985–2006. Site B was separated into two sites during 1985-1986. Circles indicate dams with fish ladders and squares indicate dams that are impassable barriers. The year of fish ladder construction is listed for dams with fish passage.

The St. Joseph River is a warmwater stream that supports a diverse fish community. Before the first dam was constructed at Niles in 1868, a number of potamodromous species had free access to the entire stream (Wesley and Duffy 1999). Lake Sturgeon, Lake Whitefish, Muskellunge, and Lake Trout from Lake Michigan occupied the St. Joseph River on a seasonal basis. In 1908, the Berrien Springs Dam was constructed, further limiting potamodromous fishes to the lower 23 miles of the river (Figure 1).

In the late 1960s and early 1970s, stocking of steelhead, Chinook Salmon, and Coho Salmon created popular fisheries in the St. Joseph River downstream of the Berrien Springs Dam. Given the popularity of this new fishery, it was decided by state and federal fisheries agencies that the St. Joseph River would be one of the locations for testing fishway designs in the Midwest using public funds. Full mitigation for the impairment and fragmentation of this river system by dams would still be ultimately borne by the dam owners, but initial fishway testing would be done using public funds. A pool-weir fish ladder was completed at the Berrien Springs Dam in 1975. Operation of this fish ladder expanded fishing opportunities for potamodromous trout and salmon 10 miles upstream to the Buchanan Dam (Figure 1). Encouraged by the results of this project, the Michigan Department of Natural Resources (MDNR), the Indiana Department of Natural Resources (IDNR), and the United States Fish and Wildlife Service (USFWS) began a collaborative process to extend this fishery upstream to the urban centers of South Bend and Mishawaka. As a result of these discussions, an interstate project was initiated to construct vertical-slot fish ladders at the Buchanan, Niles, South Bend, and Mishawaka dams using USFWS Sport Fish Restoration and Anadromous Fish Program funds along with other state funds (Figure 1). The objectives of the project were to increase annual fishing effort in the lower St. Joseph River (from Twin Branch Dam downstream to Lake Michigan) by 125,000 angler days and to spread salmonid fishing effort over a larger portion of the river (James et al. 1980). By 1992, the fish ladders were completed, allowing potamodromous salmonids to migrate 63 miles upstream from Lake Michigan to the Twin Branch Dam. As part of this project, the Richard Clay Bodine State Fish Hatchery was constructed downstream of the Twin Branch Dam to provide for IDNR's river stocking commitment. New public access sites also were developed, and improvements were made to some of the existing access sites.

In 1988, a formal written agreement between the states of Michigan and Indiana was developed to serve as a framework for managing this interstate fishery (Anonymous 1988). As part of this agreement, the states established two methods for assessing the effects of the fish ladders on the St. Joseph River fishery: fish passage counts and creel surveys. Fish passage counts have been conducted at the Niles and South Bend fish ladders since 1992. Fish passage data also has been collected at the Berrien Springs fish ladder since 1977. This data has been used to assess the efficacy of the ladders at passing various fish species, monitor trends in abundance of major game fish species, determine timing of spawning migrations, and elucidate daily movement patterns for salmonids. This information is being summarized as part of another project and will not be discussed in detail in this report.

Creel surveys were conducted from 1985 to 2006 at several sites along the river from Benton Harbor to the Twin Branch Dam to obtain information regarding the amount and distribution of fishing effort, harvest, and catch rates for the major game fish species in the St. Joseph River. The objectives of this study were to compile and summarize the creel survey data that have been collected and to examine the costs and benefits associated with management of the St. Joseph River fishery. The annual operation and maintenance of fish ladders and annual fish stocking programs (Tables 1 and 2) are significant operational expenses for MDNR and IDNR. Thus, it is in the best interest of both agencies and the anglers that support them to carefully evaluate the returns on these initial fishway investments that were known at the time to not completely mitigate the effects of the dams on fragmentation.

Table 1.–Trout and salmon stocking in the St. Joseph River downstream of the Twin Branch Dam, 1983-2009[a]. Life stage indicated in parentheses. Species codes: RBT_{MI} = Michigan strain steelhead, RBT_{SKA} = Skamania strain steelhead, CHS = Chinook Salmon, COS = Coho Salmon, and BNT = Brown Trout. Life stage codes: FF = fall fingerling, SF = spring fingerling, and Y = yearling.

	Michigan							Indiana				
Year	RBT_{MI} (Y)	RBT_{MI} (FF)	RBT_{SKA} (Y)	CHS (SF)	COS (Y)	COS (FF)	BNT (Y)	RBT_{MI} (Y)	RBT_{SKA} (Y)	RBT_{SKA} (FF)	CHS (SF)	COS (Y)
1983	40,000	164,277		300,000			31,440					
1984	17,500			250,020			36,500					
1985	40,000			190,000			14,030		165,996	60,608	407,013	
1986	53,280			221,060			16,140		168,520	91,405	355,932	
1987	67,583			204,961			16,100		175,976	48,905	258,474	
1988	62,197		6,623	200,000			16,530		172,262	53,883	377,528	
1989	43,845		19,334	400,000			16,500		175,786	38,282	186,858	
1990	41,285		13,806	404,564		291,044	16,500		176,810	44,632	153,590	
1991	57,774			310,034			16,018		182,151	39,477	148,267	
1992	58,857			354,544		217,721	16,157		177,051	53,202	173,778	
1993	59,613			282,097		105,045	16,390		180,512		166,142	
1994	62,296		47,459	371,800			30,787		172,975		168,938	
1995	64,779		35,379	474,104		165,686	15,348		160,194	18,015	190,819	
1996	71,905		17,965	399,704	150,134		19,799		176,990	57,145	209,407	75,980
1997	81,038		56,454	325,096	150,191		20,548		189,026	79,148	143,262	
1998	66,276		39,562	365,760	130,240		19,900		174,416	105,453	206,987	
1999	70,651		39,946	187,395	160,122		25,800		159,654	72,837	150,811	
2000	60,005			186,310	165,535		40,910		175,040	25,399	149,911	
2001	74,521			189,947	164,033		27,860		145,568	87,886	153,520	
2002	84,461			204,261	148,005		27,440	39,460	178,903	87,930		
2003	83,305			189,839	150,000	520,024	27,400	40,000	160,156	82,701		
2004	81,944			190,258			28,200	40,000	161,576	75,733		
2005	66,444			153,460	116,589		27,800	40,000	161,317	86,154		
2006	86,288			120,427	150,065	183,486	28,500	40,001	156,848	37,362		
2007	83,035			98,997	105,013	193,963	24,560	40,792	172,443	80,814		
2008	51,780			95,337	150,063		27,900	34,017	154,857	87,637		
2009	80,250			99,000		107,876	31,760	40,000	163,523	84,745		

[a] Includes fish stocked in the lower Paw Paw and Dowagiac rivers as these fish have unrestricted access to the St. Joseph River

Table 2.–Walleye stocking in the St. Joseph River downstream of Niles Dam, 1983–2009.

Year	Fry	Spring fingerlings	Fall fingerlings
1983		21,698	
1984	3,030,000	92,621	
1985	3,000,000	161,564	
1986	1,137,500	159,676	
1987	1,843,000	106,124	
1988	3,600,000	148,242	
1989	3,000,000	112,403	
1990			
1991		121,518	5,500
1992		86,002	
1993		103,402	
1994		72,591	
1995		91,764	
1996		53,248	
1997		110,233	
1998		56,195	
1999		227,561	
2000		127,355	
2001		151,644	
2002			
2003		101,732	
2004			
2005		50,612	
2006			
2007			
2008		54,346	
2009		62,106	

Methods

Creel Surveys

Annual creel surveys were completed at eight sites on the St. Joseph River from 1985 to 2006 (Figure 1; Table 3). Creel surveys were conducted at all sites during 1992–2004, whereas only a few of the sites were sampled during 1985–1991 and 2005–2006 (Table 4). During 1992–2004, two creel clerks covered the five sites in Michigan, and another creel clerk worked at the three sites in Indiana.

Creel survey seasons differed between years and among sites (Table 4). Creel surveys usually encompassed the spring (March–April) and fall (September–November) fishing seasons and often included at least part of the summer. On the Michigan portion of the river, creel data generally were not collected during the month of May.

Creel surveys were conducted five days each week. All weekend days were included in the survey, along with three randomly selected weekdays. Sampling typically did not occur on holidays. During 1985–1992, the fishing day was divided into two shifts (morning or afternoon-evening). Beginning in 1993, a midday shift (08:00–17:00) was added to the rotation to facilitate collection of more completed trip interviews. Each clerk worked one shift at a single site each day with the exception of clerks working at Sites D and H; these sites were surveyed during the same shift. Both shifts and sites were randomly selected.

Instantaneous counts were used to collect information on fishing effort. In general, clerks counted boats or boat trailers and shore anglers at several locations within the site twice during each shift, with count times randomly selected. Slightly different methods were used during the 1985 and 1986 creel surveys on the Indiana portion of the river. During these surveys, instantaneous counts were completed once every hour. The total number of angler hours, angler trips, and angler days were calculated from count data using the procedures described by Lockwood et al. (1999).

Angling effort is reported as estimated angler hours or estimated angler trips. Angler hours reflect total hours involved in fishing by anglers for a given time period at a given location. These fishing hours cover the time from arrival at a site to departure from that site and include within site travel times such as the time it takes an angler to walk from their parked vehicle to a chosen location within a site to fish. Angler trips reflect only the number of times anglers fish at a given location. An angler may, for example, fish several hours in the day, stop fishing and leave the site, and then return later in the day and fish several more hours. While this is a single [angler] day, multiple hours have been fished and two angler trips have been made. [From Lockwood et al. 1999]

During each shift, creel clerks attempted to conduct as many completed-trip angler interviews as possible. As the clerks could not cover all access points within a site, they concentrated their interviewing efforts at the most heavily used access locations. Interview information collected included date, site number, fishing mode (boat or shore), bait type (natural or artificial), start and end times for each fishing trip, angler's age, angler's zip code, angler's sex, species targeted, and the number of fish harvested by species. Clerks also collected data on the number of legal-size fish released for select species, beginning in 1993 for steelhead and Chinook Salmon, 1994 for Smallmouth Bass, and 1999 for Brown Trout and Coho Salmon.

During 1985 through 1996, interviews were conducted by angling party and the mean of ratios estimator was used to calculate catch per angler hour for each species (Ryckman 1981). After 1996, interview information was recorded for individual anglers and the ratio of means estimator was used to calculate catch rates (Lockwood et al. 1999). Estimated catch for each species was the product of the catch rate and estimated fishing effort.

Table 3.–Creel survey sites on the St. Joseph and Dowagiac rivers, 1985–2006.

Site	Stream	Downstream boundary	Upstream boundary	Length (river miles)	MDNR Creel Program site code
A	St. Joseph River	Carronde Park	Jasper Dairy boat launch	9.6	367
B	St. Joseph River	Jasper Dairy boat launch	Berrien Springs Dam	10.3	298
C	St. Joseph River	Berrien Springs Dam	Buchanan Dam	10.1	345
D	St. Joseph River	Buchanan Dam	Niles Dam	9.5	387
E	St. Joseph River	Michigan-Indiana state line	South Bend Dam	7.9	388
F	St. Joseph River	South Bend Dam	Mishawaka Dam	4.3	389
G	St. Joseph River	Mishawaka Dam	Twin Branch Dam	2.7	390
H	Dowagiac River	Mouth	Pucker Street Dam	2.9	391

Table 4.–Months during which creel data were collected at each site on the St. Joseph and Dowagiac rivers, 1985–2006. A "–" indicates that no data were collected. (See Figure 2 for site locations.)

Year	Michigan				Indiana			Michigan
	Site A	Site B	Site C	Site D	Site E	Site F	Site G	Site H
1985	–	4–11	4–10	–	5–10	5–10	5–10	–
1986	–	3–5, 9–12	–	–	5–10	5–10	5–10	–
1987	6–10	3, 6–10	–	–	–	–	–	–
1988	6–12	3–4, 6–12	–	–	–	–	–	–
1989	2–4, 7–12	2–4, 7–12	–	–	–	–	–	–
1990	3–5, 7–12	3–5, 7–12	–	–	–	–	–	–
1991	3–4, 8–12	3–4, 8–12	3–4, 8–12	3–4, 8–12	–	–	–	–
1992	6–12	3–4, 6–12	3–4, 10	3–4, 10	3–4, 10–11	3–4	3–4, 9–12	10–11
1993	3–4, 6–11	2–4, 6–12	3–4, 7–11	4, 7–9, 12	3–4, 7–12	3–4, 7–8, 10	3–4, 7–12	4, 7–11
1994	3–4, 6–12	2–4, 6–12	3, 6–10	3, 6–8, 10–12	3–4, 7–11	3–4, 7–11	3–4, 7–12	3–4, 9–11
1995	3, 6–12	2–4, 6–12	3, 6–10	3–4, 6–10, 12	3–4, 7–11	3–4, 7–11	3–4, 7–11	4, 7, 9–12
1996	3–4, 6–12	3–4, 6–7, 9–12	3–4, 6–10	3–4, 6–11	3–4, 7–11	3, 7–12	3–4, 7–12	3–4, 7–11
1997	3–4, 6–12	3–4, 6–12	3–4, 6–11	3–4, 6–11	3–4, 7–11	3–4, 7–11	3–4, 7–11	3–4, 6–11
1998	3–4, 6–12	3–4, 6–12	3–4, 6–12	3–4, 6–12	3–11	3–11	3–11	3–4, 6–12
1999	3–4, 6–12	3–4, 6–12	3–4, 6–12	3–4, 6–12	3–11	3–11	3–11	3–4, 6–12
2000	3–4, 6–12	3–4, 6–12	3–4, 6–12	3–4, 6–12	3–11	3–11	3–11	3–4, 6–12
2001	3–4, 6–12	3–4. 6–12	3–4, 6–12	3–4, 6–12	3–11	3–11	3–11	3–4, 6–12
2002	3–4, 6–12	3–4, 6–12	3–4, 6–12	3–4, 6–12	3–11	3–11	3–11	3–4, 6–12
2003	3–4, 6–12	3–4, 6–12	3–4, 6–12	3–4, 6–12	3–11	3–11	3–11	3–4, 6–12
2004	3–4, 6–12	3–4, 6–12	3–4, 6–12	3–4, 6–12	3–11	3–11	3–11	3–4, 6–12
2005	–	3–11	–	–	3–11	3–11	3–11	–
2006	–	3–10	–	–	–	–	–	3–4, 10

Variation in creel survey coverage complicated analysis of basinwide trends in fishing effort or harvest (Table 4). To evaluate the seasonal and spatial distribution of fishing effort on the St. Joseph River during 1992–2004, the fishing year was divided into three seasons: spring (March–April), summer (July–August), and fall (September–October). Mean fishing effort for each site during each season was calculated. While effort estimates for some sites and seasons were not available, all available estimates were included in the mean effort calculations. These individual means were summed to obtain seasonal estimates of fishing effort for the entire study area for each year.

It was hypothesized that annual fish passage at the Berrien Springs Dam was correlated with annual catch of salmonids at all creel survey sites. Spearman's rank correlation test was used to evaluate correlations between upstream fish passage (data on file) and basinwide catch of Rainbow Trout, Chinook Salmon, Coho Salmon, and Brown Trout during 1994–2004. These years were selected for the correlation analysis because creel survey coverage was relatively consistent throughout this period (Table 4).

Cost-benefit Analyses

The economic benefits of the lower St. Joseph and Dowagiac rivers noncharter recreational fisheries for the surrounding communities were estimated using the angler expenditure data provided by United States Department of the Interior et al. (2008b) for the State of Michigan. To derive economic value estimates, United States Department of the Interior et al. (2008b) interviewed anglers from 942 households to collect data on all fishing related expenditures, including food, lodging, transportation, bait, and fishing tackle. For noncharter anglers, the estimated economic value of one angler day was $24 in 2006. The economic values of the fisheries in the lower St. Joseph and Dowagiac rivers were calculated using fishing effort data from 1997–2004. These years were selected for the analysis because creel survey coverage was relatively consistent at all sites and targeted effort data was available for this period.

To assess the economic value of the charter fishery, the average cost for charter services was estimated by checking the websites for several of the charter boat captains on the lower St. Joseph River. Based on this review, it appeared that the average cost for a charter excursion was approximately $100 per angler day. The charter fees were added to the $24/angler day estimate from United States Department of the Interior et al. (2008b) to yield an economic value estimate of $124/angler day for anglers using charter services in the lower St. Joseph River. This value was multiplied by the number of angler days reported by charter boat captains in the lower St. Joseph River during 1997–2004 (www.dnr.state.mi.us/chartercreel). Because the St. Joseph River downstream of the Berrien Springs Dam is designated as a navigable water, any fishing guide operating on this section of the river must have a charter captain's license and is required to report his monthly fishing activity to the MDNR. Fishing guides operating upstream of Berrien Springs Dam typically have a different type of license and are not required to provide monthly reports to the MDNR.

For the cost analysis, both construction costs and annual maintenance costs were estimated. The construction costs for the fish ladders and the Richard Clay Bodine State Fish Hatchery were determined from MDNR and IDNR files. These costs were converted to 2006 dollars using the gross domestic product deflator conversion from MeasuringWorth.com (www.measuringworth.com/uscompare; March 2011).[1]

[1] All cost conversions were completed using the tools at MeasuringWorth.com. Different conversion tools were used depending on the nature of the expenditure. The gross domestic product deflator was used for construction projects, the unskilled wage conversion was used for salaries, and the consumer price index was used for transportation, maintenance, and fish production costs.

To estimate the mean annual maintenance costs for the fish ladders, the annual costs for 2004–2007 were determined. This period was selected for the annual cost analysis for two reasons. The United States Department of the Interior et al. (2008b) fishing expenditures survey was conducted in 2006, so it seemed logical to center the cost analysis on that year. In addition, the MDNR fish ladder operator was on staff during most of this period, so the cost estimates accurately reflect the preferred level of staffing for fish ladder maintenance.

Fishery maintenance costs were separated into four categories: salaries, transportation, contractual services/supplies/materials (CSSM), and fish stocking. In MDNR Fisheries Division, personnel time, vehicle usage, and all purchases were coded by project. Thus, it was possible to calculate the total wages coded to fish ladder maintenance and operation. Time dedicated to assessing fish passage through the ladders was included in the cost estimates as such efforts are necessary to determine if the ladders are functioning correctly. However, time dedicated to creel surveys was not included in the cost analysis. When calculating salaries, the total wages were multiplied by 1.45 to account for benefit costs. Transportation costs included daily fees for vehicle usage and charges per mile. The CSSM costs included costs for materials, equipment, contractor services, electrical and phone services, and other miscellaneous expenses associated with maintenance of the fish ladders. Salary costs were adjusted to 2006 dollars using the unskilled wage conversion, and transportation and CSSM costs were adjusted using the consumer price index conversion. Due to differences in accounting procedures, it was not possible to conduct such a detailed cost analysis for IDNR. Total annual costs were available for 1998–2003. These costs were converted to 2006 dollars using the unskilled wage conversion.

The numbers and species of fish stocked in the lower St. Joseph and Dowagiac rivers have varied over time. For the fish stocking cost calculations, the numbers, species, and life stages of fish to be stocked were obtained from the 1997–2004 stocking records. MDNR calculated fish production cost estimates for spring fingerling Chinook Salmon, yearling Brown Trout (Wild Rose strain), yearling Rainbow Trout (Michigan strain), and yearling Coho Salmon for the 2009 fiscal year. The most recent cost/fish estimates for spring fingerling Walleye were from 1984. All MDNR fish stocking cost estimates were converted to 2006 dollars using the consumer price index conversion. Detailed cost estimates for fall fingerling Coho Salmon were not available, but hatchery staff provided an estimate based on the total cost per kilogram for all fish reared at the Platte River State Fish Hatchery during the 2006 fiscal year (Ed Eisch, MDNR Fisheries Division, personal communication). For IDNR, fish stocking cost estimates were available for 2002–2004. These estimates were converted to 2006 dollars using the consumer price index conversion and averaged to obtain the mean cost/fish for the IDNR stocking program.

Construction costs and annual maintenance expenditures for the St. Joseph River public access sites were not included in this cost analysis. Although these access sites certainly are a benefit to anglers, they also are used by recreational boaters, kayakers, and canoeists. Thus, the costs for these facilities are not solely related to continuation of the fishery in the lower St. Joseph River.

Results

Effort

During 1992–2004, fishing effort along the lower St. Joseph River generally increased from spring through fall. Mean seasonal effort, calculated using all sites combined, was 57,873 angler hours for March–April, 98,595 angler hours for July–August, and 130,324 angler hours for September–October. There was substantial seasonal variation in the spatial distribution of fishing effort. During March–April (1992–2004), 72% and 28% of the effort occurred in the Michigan and Indiana portions of the basin, respectively (Figure 2). Fishing effort was greatest below the Berrien Springs Dam (site B), with 44% of the total effort expended at this site. The mean seasonal effort on the Dowagiac River (site H) was greater than the effort recorded at four sites on the main stem.

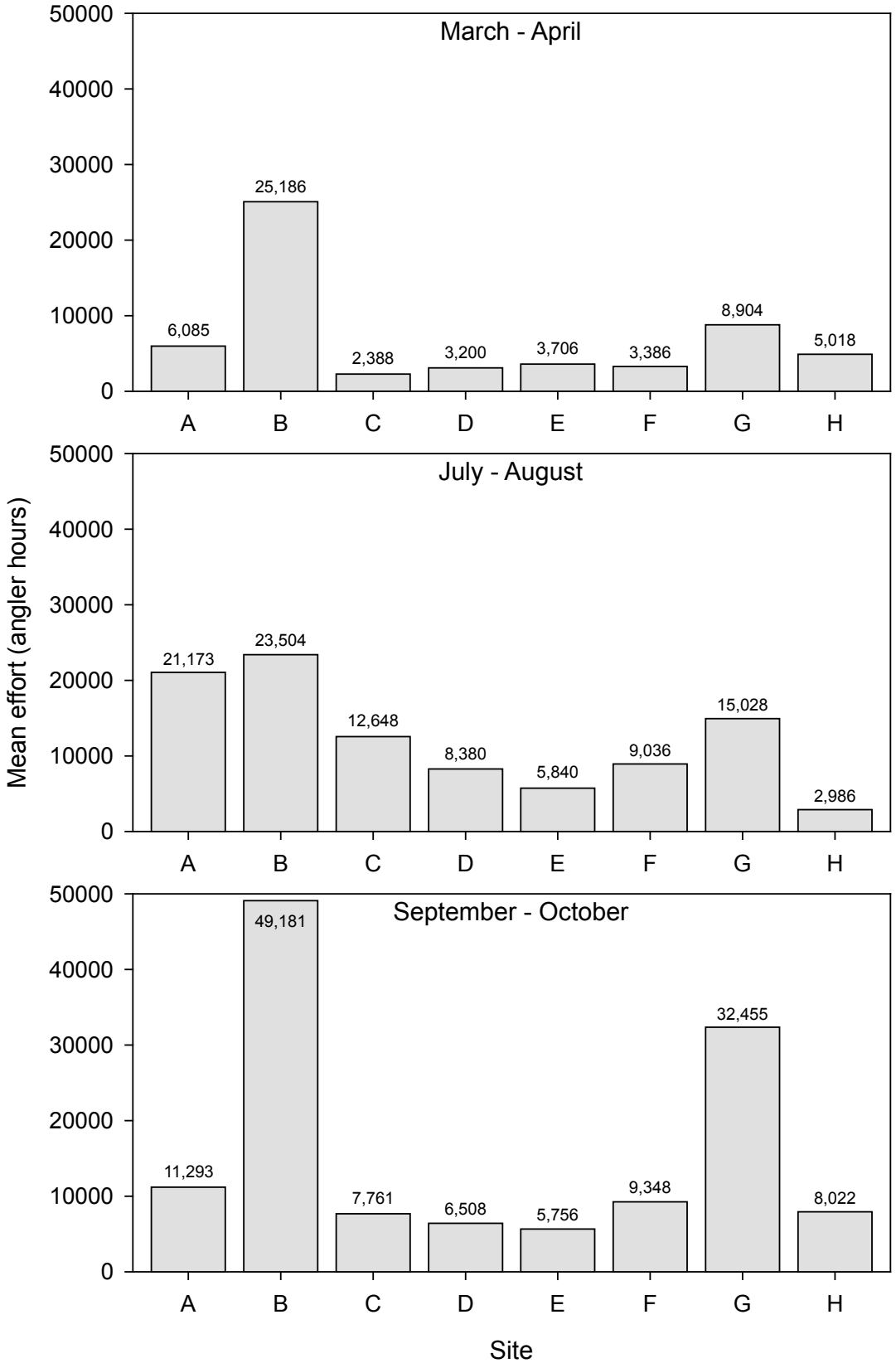


Figure 2.–Spatial distribution of seasonal fishing effort on the St. Joseph and Dowagiac rivers, 1992–2004. Sites are listed in order from downstream to upstream. Site H is the Dowagiac River. (See Figure 1 for site locations.)

During July–August, 70% and 30% of the effort occurred in Michigan and Indiana, respectively (Figure 2). Effort was more evenly distributed between the creel sites in the summer than in the spring. Approximately 45% of the total fishing effort occurred at the two lowermost sites (A and B). Fishing pressure on the Dowagiac River was low relative to the spring and fall periods.

The spatial distribution of fishing effort during September–October was similar to the spring; however, effort below Twin Branch Dam (site G) was much greater in the fall (Figure 2). Sixty-three percent of the total fishing effort was recorded at sites B and G. During the fall, 64% and 36% of the effort occurred in the Michigan and Indiana portions of the basin, respectively.

During 1992–2004, the mean annual fishing effort for all creel survey sites on the St. Joseph and Dowagiac rivers was 349,595 angler hours. Similar long-term effort estimates were not available for other Michigan rivers, but effort estimates were available for portions of the Manistee and Muskegon rivers from 1999 through 2004. For this period, the mean annual fishing effort on the lower St. Joseph River system was lower than the mean effort on the Manistee River and similar to the mean effort on the Muskegon River (Figure 3a). The St. Joseph River creel survey encompassed 57.3 river miles, whereas the Manistee and Muskegon surveys only covered 14.9 and 14.3 river miles, respectively. To facilitate site comparisons, fishing pressure was calculated in terms of angler hours per river mile (Figure 3b). Fishing pressure estimates for most of the St. Joseph River sites were substantially lower than fishing pressure estimates at the Manistee and Muskegon sites. Site G (Mishawaka Dam to Twin Branch Dam) had the highest fishing pressure of the St. Joseph River sites. The fishing pressure at Site G was comparable to the estimated fishing pressure on the Muskegon River.

Temporal trends in fishing effort varied by season and sampling location. For March–April and July–August, there were no obvious long-term trends in fishing effort (Figures 4 and 5). For September–October, fishing effort was substantially higher at the three Indiana sites after the fish ladders were constructed (Figure 6). Effort also appeared to be increasing in the lower Dowagiac River, but no effort data were collected at this site prior to ladder construction. A long-term decline in fishing effort was observed at sites A and B, especially downstream of the Jasper Dairy DNR boat launch site. No temporal trends in effort were observed between the Berrien Springs and Niles dams (sites C and D).

State of residency was recorded for 17,095 angler interviews during 1985–1990 and 1996–2006. Approximately 90% of the anglers interviewed were residents of Michigan or Indiana (Figure 7). Eight percent of the anglers were from Illinois, and the remaining 2% were residents of other states or countries. Anglers from 35 states, Canada, and Guam were interviewed during the creel surveys on the St. Joseph and Dowagiac rivers.

Angler demographics varied between sites (Figure 8). Nearly half of the anglers interviewed below Berrien Springs Dam (site B) were not Michigan residents. Below the Jasper Dairy DNR boat launch site (site A), 71% of the anglers were Michigan residents. Fewer out-of-state anglers were interviewed upstream of the Berrien Springs Dam (sites C and D). On the Dowagiac River (site H), 76% of the anglers interviewed were Michigan residents. Few out-of-state anglers were encountered during creel surveys in the Indiana portion of the river. At sites E–G, 96% to 98% of the anglers interviewed were Indiana residents.

Targeted effort estimates were calculated for all sites during 1997–2004. During this period, 62% of the total fishing effort was directed toward salmonids, 11% was directed toward Walleye, and the remaining 27% was directed toward other species or no particular species (Table 5). The majority of anglers interviewed at sites B, G, and H were targeting salmonids. Walleye fishing effort was greatest downstream of the Jasper Dairy DNR boat launch site (site A; 34%), whereas few Walleye anglers were encountered at sites E, G, and H.

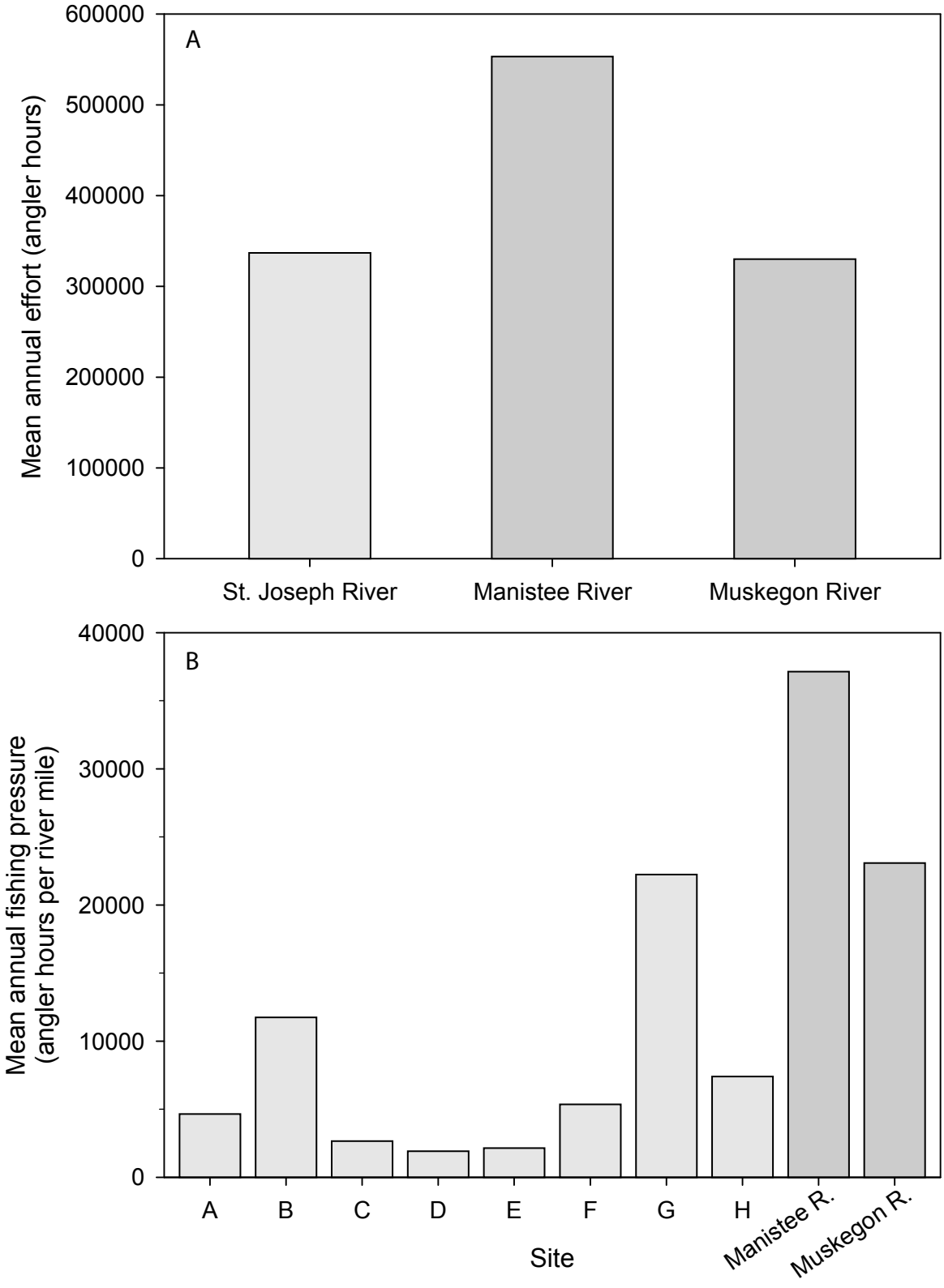


Figure 3.–Mean annual fishing effort (A) and mean annual fishing pressure (B) for the St. Joseph, Manistee, and Muskegon rivers, 1999-2004 (Zhenming Su, MDNR Fisheries Division, unpublished). The Manistee River site extended from Bear Creek to Tippy Dam. The Muskegon River site extended from the Newaygo public access site to Croton Dam. See Figure 1 for site locations on the St. Joseph River system.

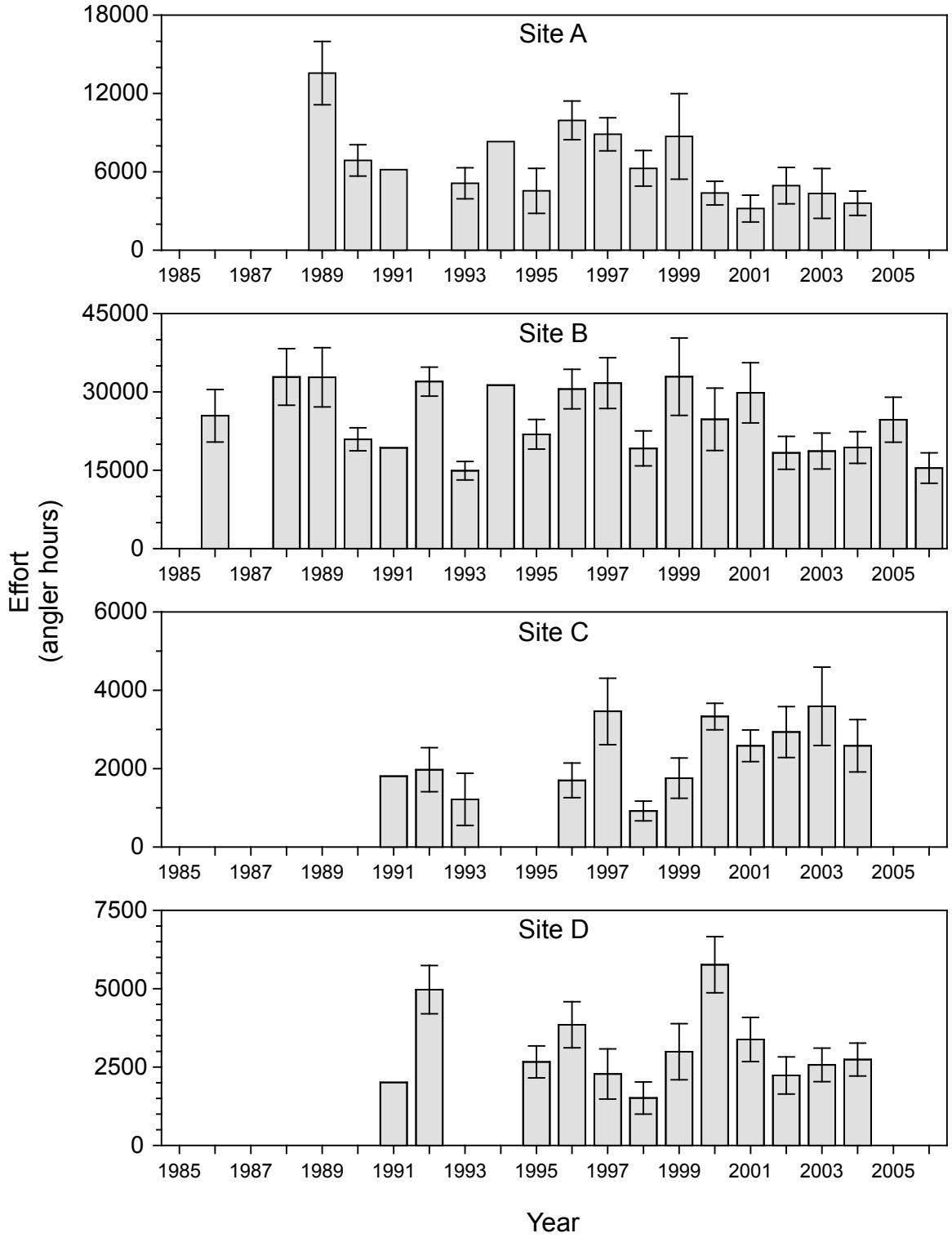


Figure 4a.–Annual spring (March-April) fishing effort for four Michigan sites on the St. Joseph River, 1985–2006. Lines represent two standard errors. The absence of a bar indicates that no creel data were collected. See Figure 1 for site locations.

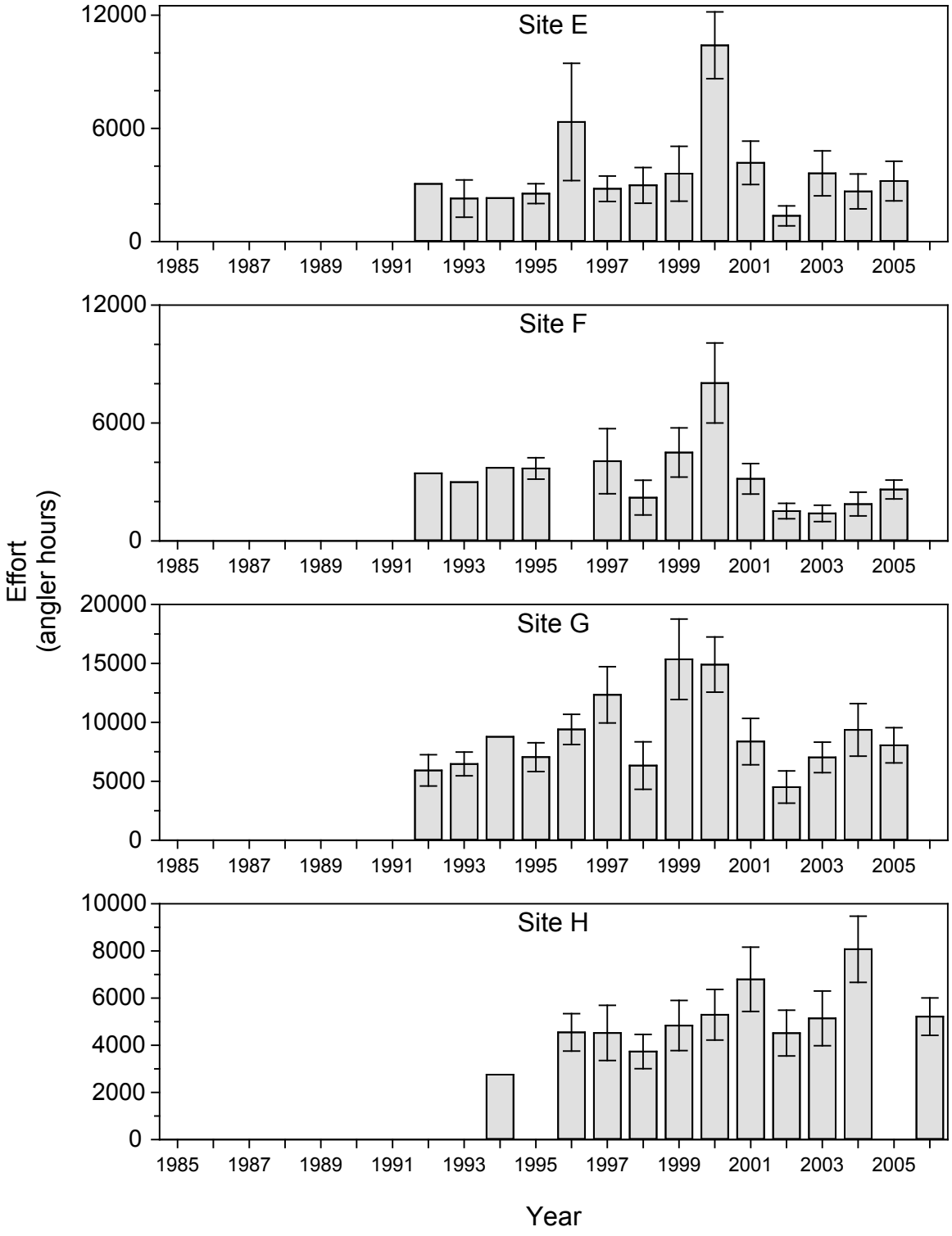


Figure 4b.–Annual spring (March–April) fishing effort for three Indiana sites on the St. Joseph River and site H on the Dowagiac River (Michigan), 1985–2006. Lines represent two standard errors. The absence of a bar indicates that no creel data were collected. See Figure 1 for site locations.

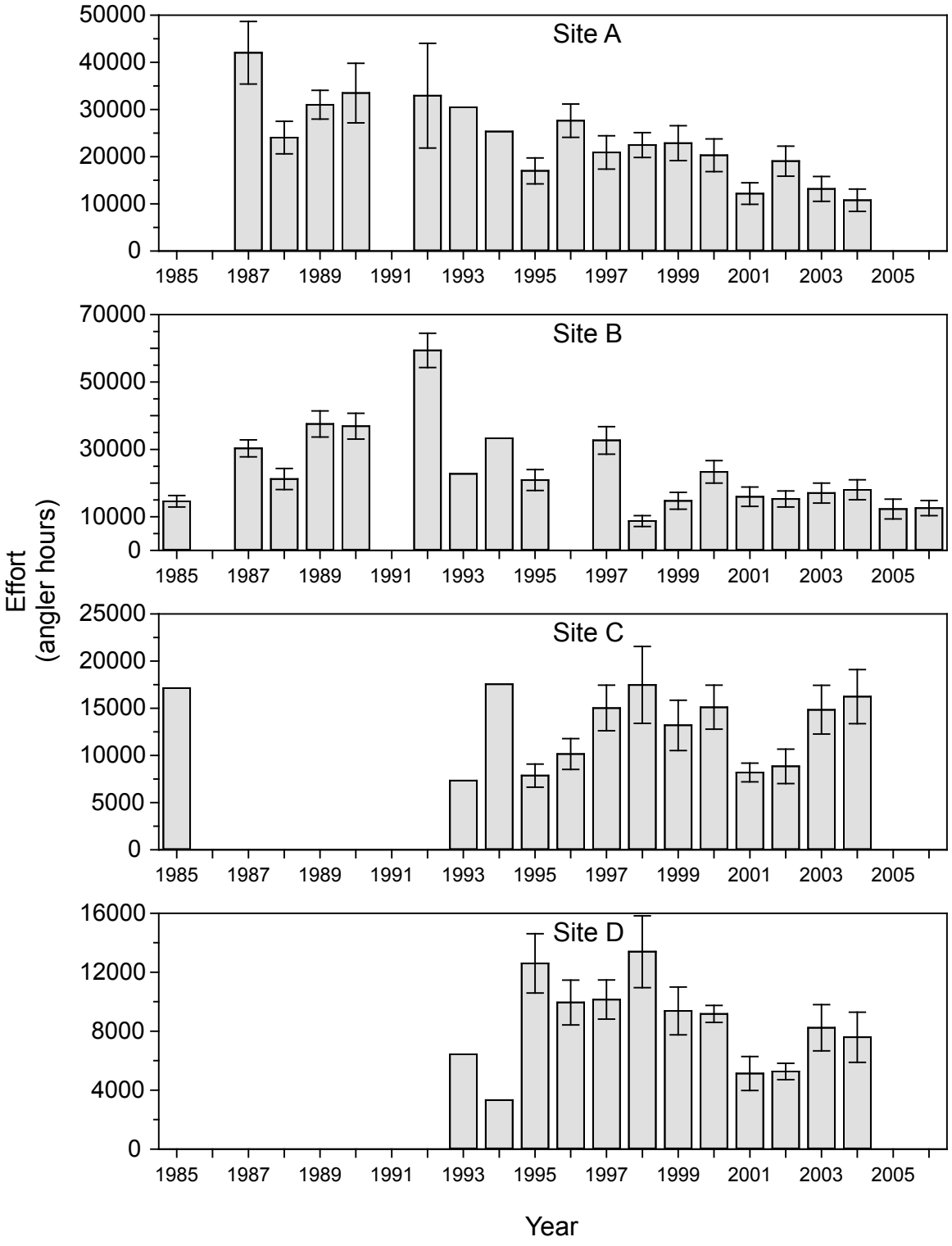


Figure 5a.–Annual summer (July–August) fishing effort for four Michigan sites on the St. Joseph River, 1985–2006. Lines represent two standard errors. The absence of a bar indicates that no creel data were collected. See Figure 1 for site locations.

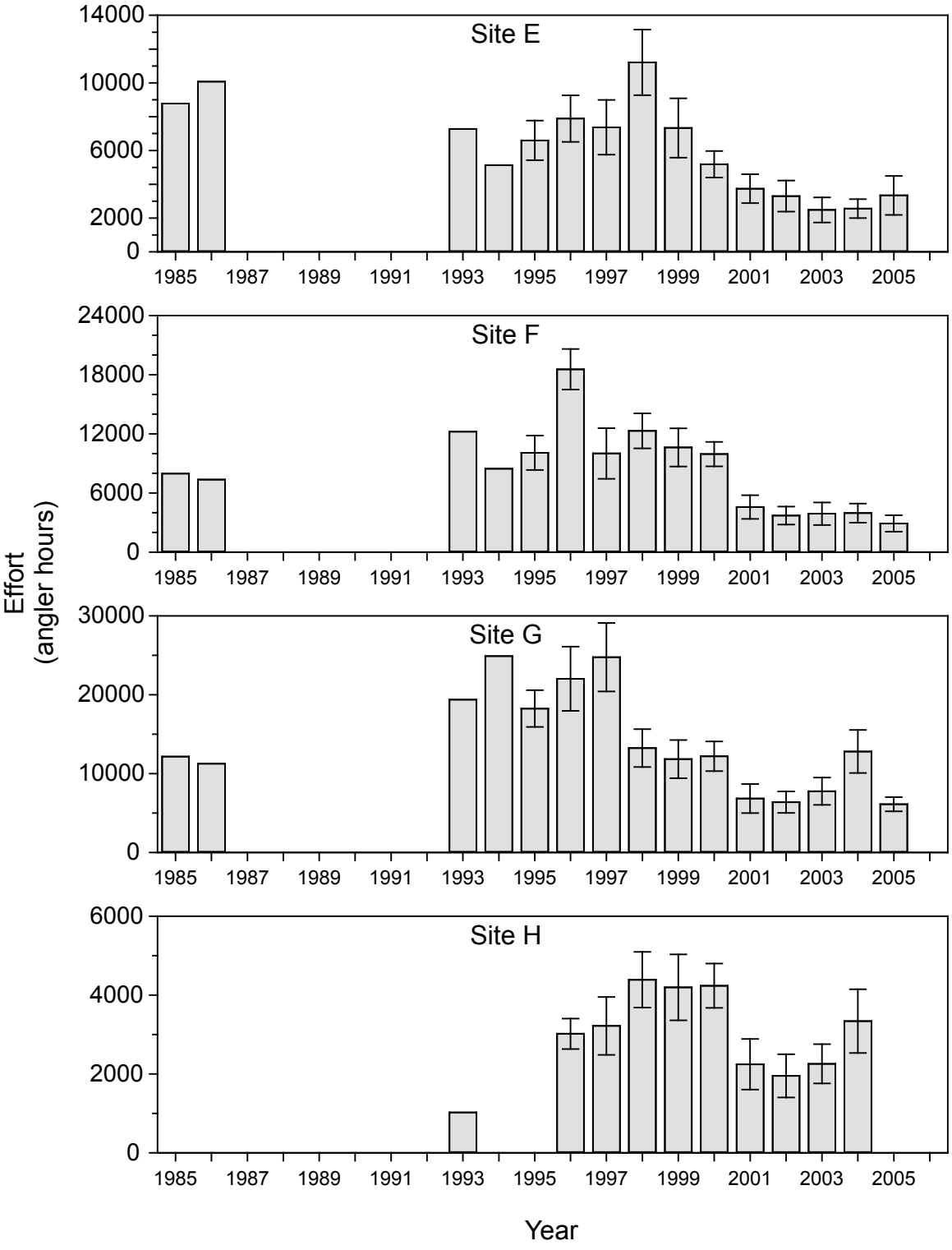


Figure 5b.–Annual summer (July–August) fishing effort for three Indiana sites on the St. Joseph River and site H on the Dowagiac River (Michigan), 1985–2006. Lines represent two standard errors. The absence of a bar indicates that no creel data were collected. See Figure 1 for site locations.

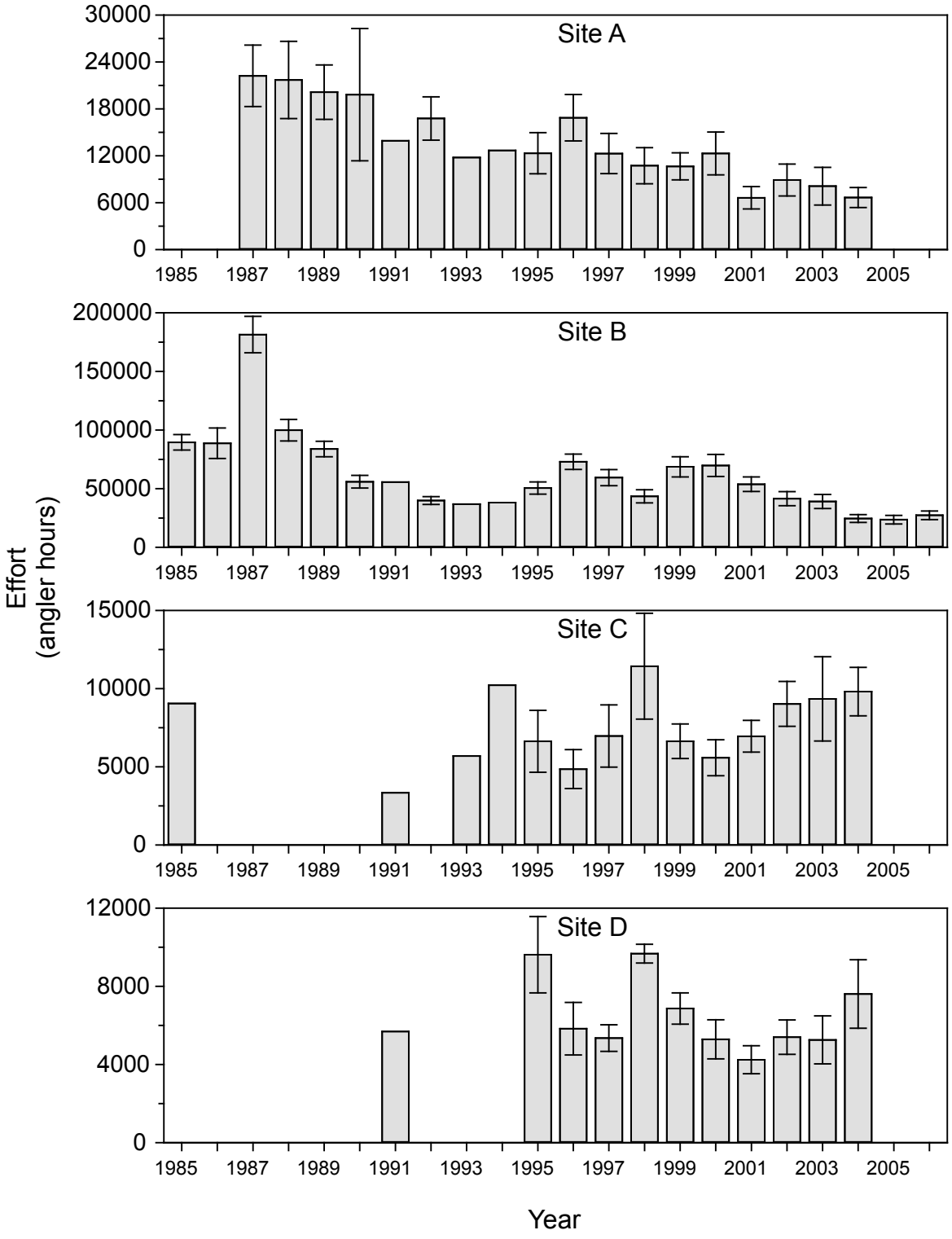


Figure 6a.–Annual fall (September–October) fishing effort for four Michigan sites on the St. Joseph River, 1985–2006. Lines represent two standard errors. The absence of a bar indicates that no creel data were collected. See Figure 1 for site locations.

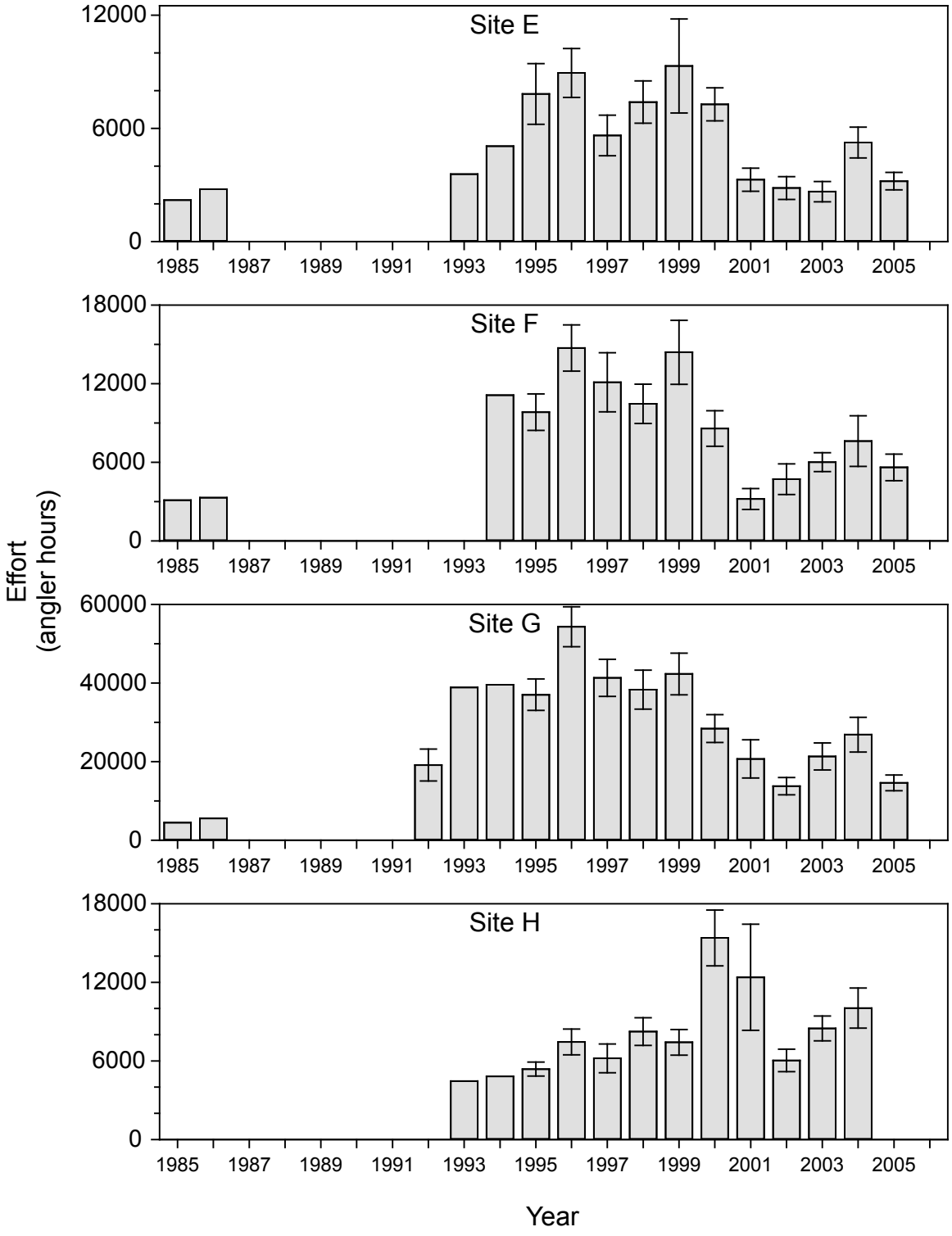


Figure 6b.–Annual fall (September–October) fishing effort for three Indiana sites on the St. Joseph River and site H on the Dowagiac River (Michigan), 1985–2006. Lines represent two standard errors. The absence of a bar indicates that no creel data were collected. See Figure 1 for site locations.

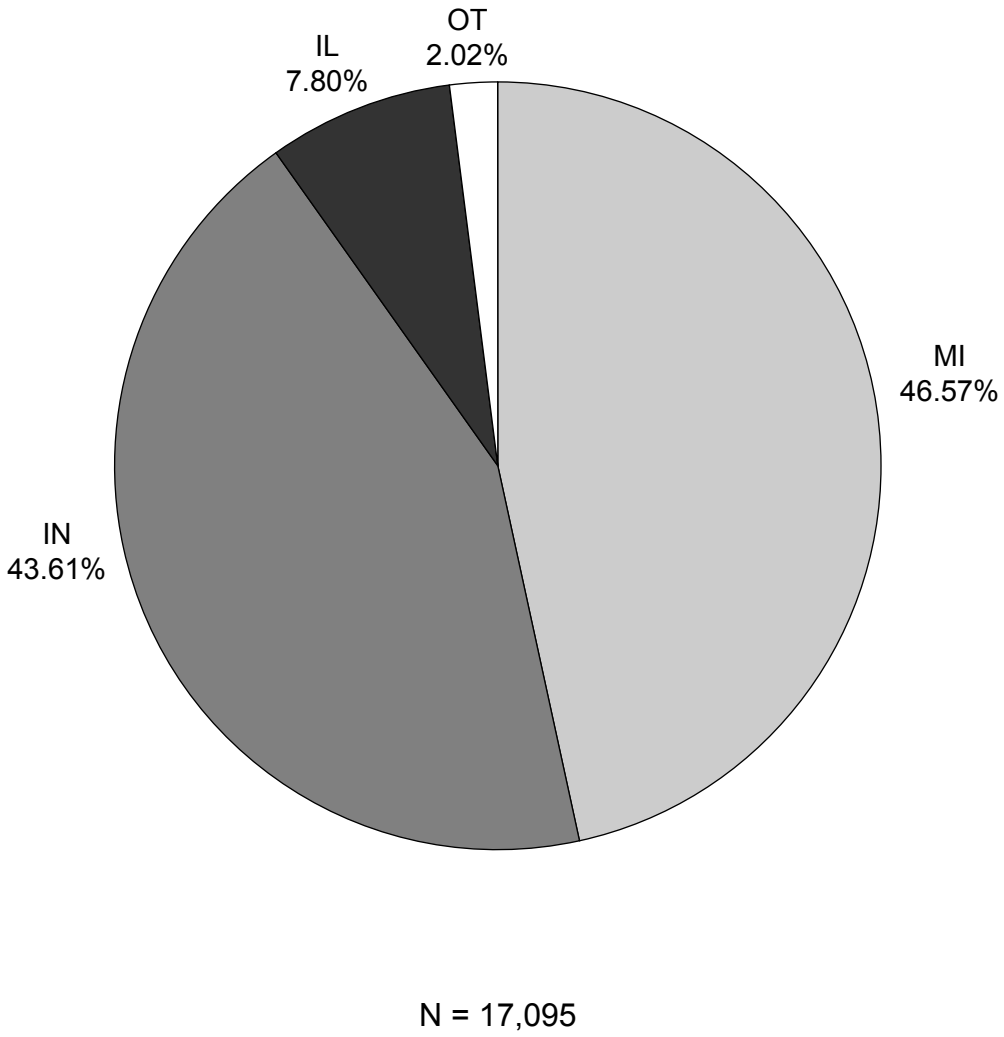


Figure 7.–Residency of St. Joseph River anglers as determined by angler interviews conducted during 1985–1990 and 1996–2006. MI = Michigan, IN = Indiana, IL = Illinois, OT = other.

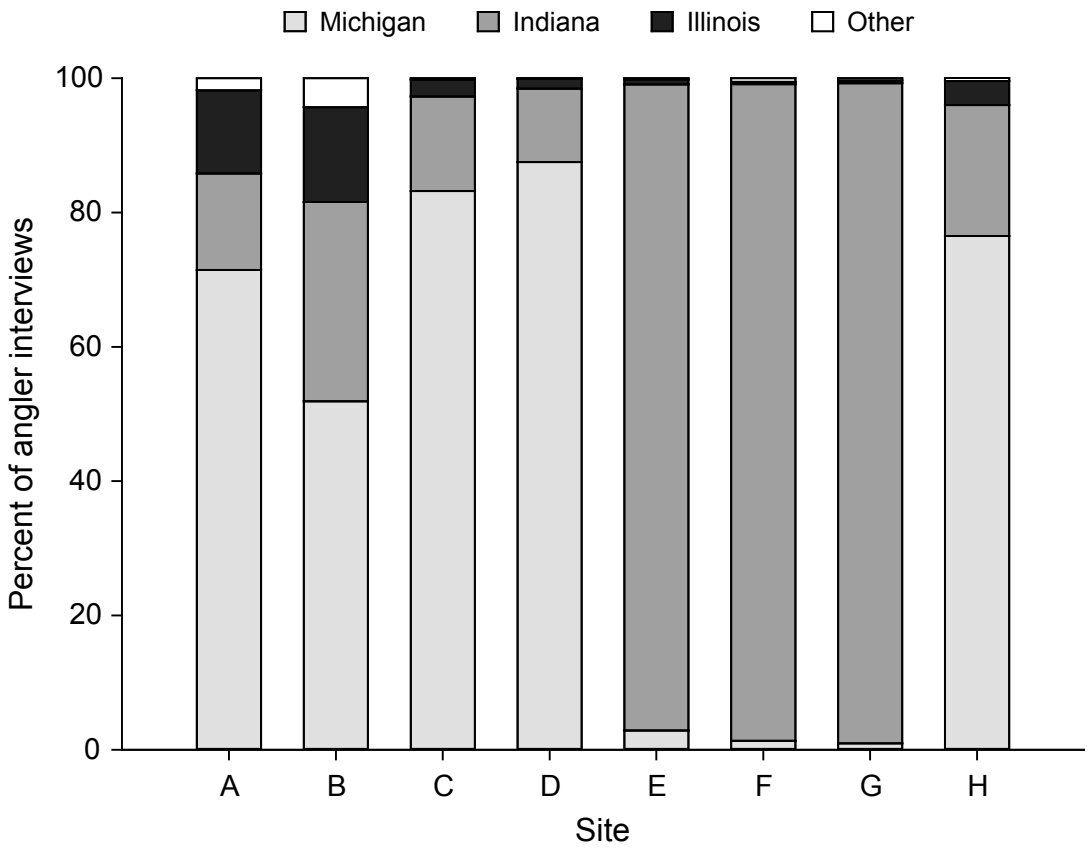


Figure 8.–Angler residency as determined by angler interviews conducted at each creel survey site on the St. Joseph and Dowagiac rivers during 1985–1990 and 1996–2006. See Figure 1 for site locations.

Table 5.–Targeted effort estimates for the St. Joseph and Dowagiac rivers, 1997–2004. The salmonids category includes steelhead, Chinook Salmon, Coho Salmon, and Brown Trout. (See Figure 2 for site locations.)

Site	Total effort (angler hours)	% effort targeting salmonids	% effort targeting Walleye	% effort targeting any species
A	402,911	32.0	33.6	34.3
B	989,655	77.1	8.9	13.9
C	233,327	43.6	16.0	40.4
D	175,637	39.5	15.1	45.4
E	147,873	45.6	2.5	51.9
F	213,000	45.1	12.0	42.8
G	529,524	72.1	1.1	26.8
H	172,294	92.1	0.4	7.5
All	2,864,221	61.7	11.3	27.0

Species Composition

During 1992–2004, the total estimated harvest for the study area was 529,300 fish (Table 6). More than 27 fish species were included in the harvest during this period. Rainbow Trout (steelhead) was the most abundant species, composing 29.4% of the total harvest (Figure 9). The other salmonid species made up much smaller percentages of the total harvest (Chinook Salmon = 6.5%, Coho Salmon = 2.1%, and Brown Trout = 1.7%). The major nonsalmonid species harvested were Bluegill (16.2%), Walleye (11.1%), Channel Catfish (6.4%), and Smallmouth Bass (6.1%).

The species composition of the harvest varied between sites (Figure 10). The portion of the total harvest composed of salmonids ranged from 20.2% to 51.8% for sites on the St. Joseph River. On the Dowagiac River (site H), salmonids made up 83.6% of the total harvest.

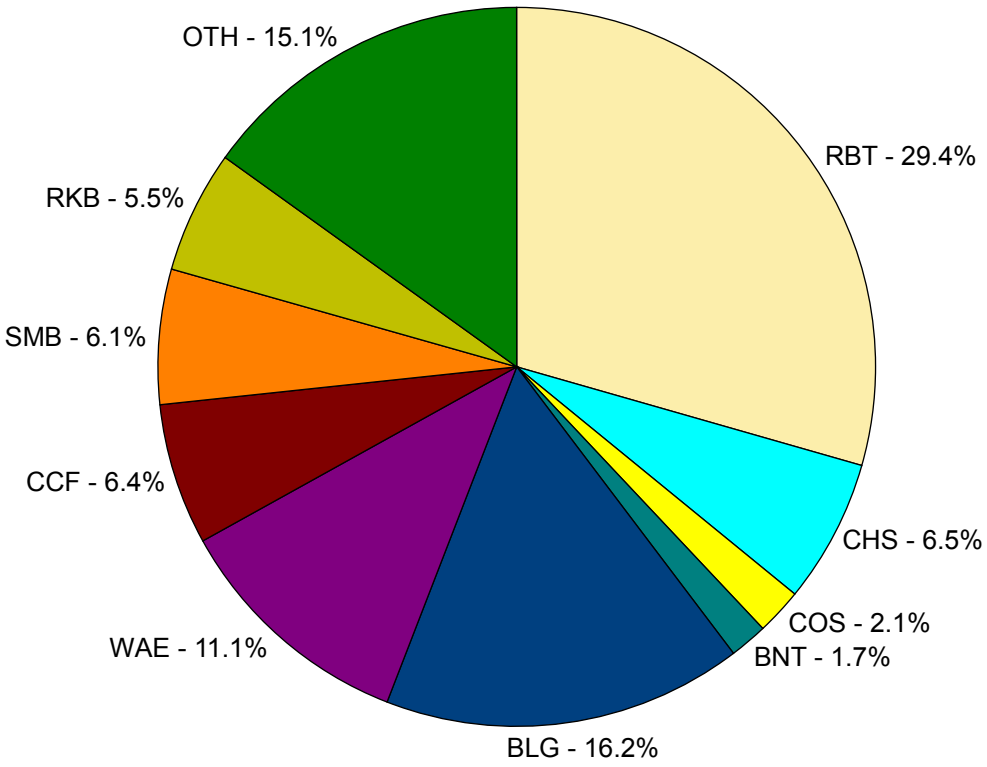
Walleye composed 15.6% of the harvest downstream of the Niles Dam (sites A–D), whereas this species only made up 3.6% of the harvest at the Indiana sites (sites E–G). A contrasting pattern was observed for Bluegill. Bluegills composed 10.3% of the harvest downstream of the Niles Dam (sites A–D) and 27.8% of the harvest at the Indiana sites (sites E–G). Walleye and Bluegill were minor components of the harvest in the Dowagiac River (site H). Smallmouth Bass made up 19.9% of the harvest between the Mishawaka Dam and the state line (sites E and F), but this species only composed 4.1% of the total harvest at the other creel survey sites.

Other fish species were important components of the harvest at individual sites. For example, Rock Bass was the most abundant species in the harvest between the Buchanan and Niles dams (site D; Figure 10). Freshwater Drum (included within the "other" category) was the second most abundant species downstream of the Jasper Dairy DNR boat launch site (site A), composing 19.2% of the total harvest.

Table 6.–Harvest estimates (number of fish) and fishing effort (angler hours and angler days) for the St. Joseph and Dowagiac rivers, 1992–2004. Harvest per angler hour estimates in parentheses. (See Figure 2 for site locations.)

	Michigan				Indiana			Michigan	
Species	A	B	C	D	E	F	G	H	Total
Bluegill	352 (0.0005)	28,373 (0.0171)	1,884 (0.0058)	3,322 (0.0138)	6,293 (0.0281)	4,185 (0.0133)	41,237 (0.0470)	210 (0.0010)	85,849 (0.0189)
Brown Trout	2,895 (0.0042)	4,886 (0.0029)	277 (0.0009)	67 (0.0003)	6 (0.0000)	13 (0.0000)	211 (0.0002)	693 (0.0033)	9,047 (0.0020)
Channel Catfish	10,263 (0.0148)	8,589 (0.0052)	4,641 (0.0143)	870 (0.0036)	491 (0.0022)	2,284 (0.0072)	6,554 (0.0075)	0 (0.0000)	33,691 (0.0074)
Chinook Salmon	1,172 (0.0017)	21,000 (0.0127)	707 (0.0022)	578 (0.0024)	1,672 (0.0075)	3,117 (0.0099)	2,324 (0.0027)	3,629 (0.0171)	34,196 (0.0075)
Coho Salmon	690 (0.0010)	2,668 (0.0016)	1,816 (0.0056)	989 (0.0041)	130 (0.0006)	355 (0.0011)	2,677 (0.0031)	1,692 (0.0080)	11,013 (0.0024)
Freshwater Drum	16,259 (0.0234)	5,532 (0.0033)	17 (0.0001)	0 (0.0000)	0 (0.0000)	0 (0.0000)	294 [a] (0.0003)	0 (0.0000)	22,104 (0.0049)
Other	8,058 (0.0116)	13,161 (0.0079)	4,378 (0.0135)	5,309 (0.0221)	2,189 (0.0098)	1,130 (0.0036)	6,595 (0.0075)	820 (0.0039)	41,642 (0.0092)
Rainbow Trout	12,363 (0.0178)	67,310 (0.0406)	9,382 (0.0290)	3,824 (0.0159)	4,229 (0.0189)	10,330 (0.0327)	43,914 (0.0501)	4,427 (0.0208)	155,778 (0.0343)
Rock Bass	2,221 (0.0032)	5,183 (0.0031)	4,644 (0.0144)	5,700 (0.0237)	2,101 (0.0094)	3,229 (0.0102)	6,078 (0.0069)	11 (0.0001)	29,187 (0.0064)
Smallmouth Bass	1,970 (0.0028)	4,186 (0.0025)	2,119 (0.0066)	2,078 (0.0086)	6,909 (0.0308)	5,994 (0.0190)	8,830 (0.0101)	56 (0.0003)	32,158 (0.0071)
Walleye	24,165 (0.0348)	21,851 (0.0132)	2,828 (0.0087)	2,829 (0.0118)	607 (0.0027)	4,399 (0.0139)	1,640 (0.0019)	310 (0.0015)	58,627 (0.0129)
White Sucker	1,017 (0.0015)	2,228 (0.0013)	946 (0.0029)	1,387 (0.0058)	3,891 (0.0174)	1,251 (0.0040)	1,152 (0.0013)	645 (0.0030)	12,516 (0.0028)
Yellow Perch	3,107 (0.0045)	141 (0.0001)	115 (0.0004)	110 (0.0005)	0 (0.0000)	0 (0.0000)	14 (0.0000)	0 (0.0000)	3,487 (0.0008)
Total harvest	84,532 (0.1217)	185,108 (0.1117)	33,754 (0.1043)	27,063 (0.1125)	28,518 (0.1273)	36,287 (0.1150)	121,520 (0.1386)	12,493 (0.0588)	529,300 (0.1165)
Angler hours	694,327	1,657,303	323,488	240,576	223,998	315,641	876,804	212,607	4,544,737
Angler days	151,211	330,915	83,072	84,597	73,981	120,379	245,020	64,528	1,153,891

[a] Identification questionable



RBT = steelhead
CHS = Chinook Salmon
COS = Coho Salmon
BNT = Brown Trout
BLG = Bluegill
WAE = Walleye
CCF = Channel Catfish
SMB = Smallmouth Bass
RKB = Rock Bass
OTH = other fish species

Figure 9.–Species composition of the harvest (by number) at all sites on the St. Joseph and Dowagiac rivers, 1992–2004.

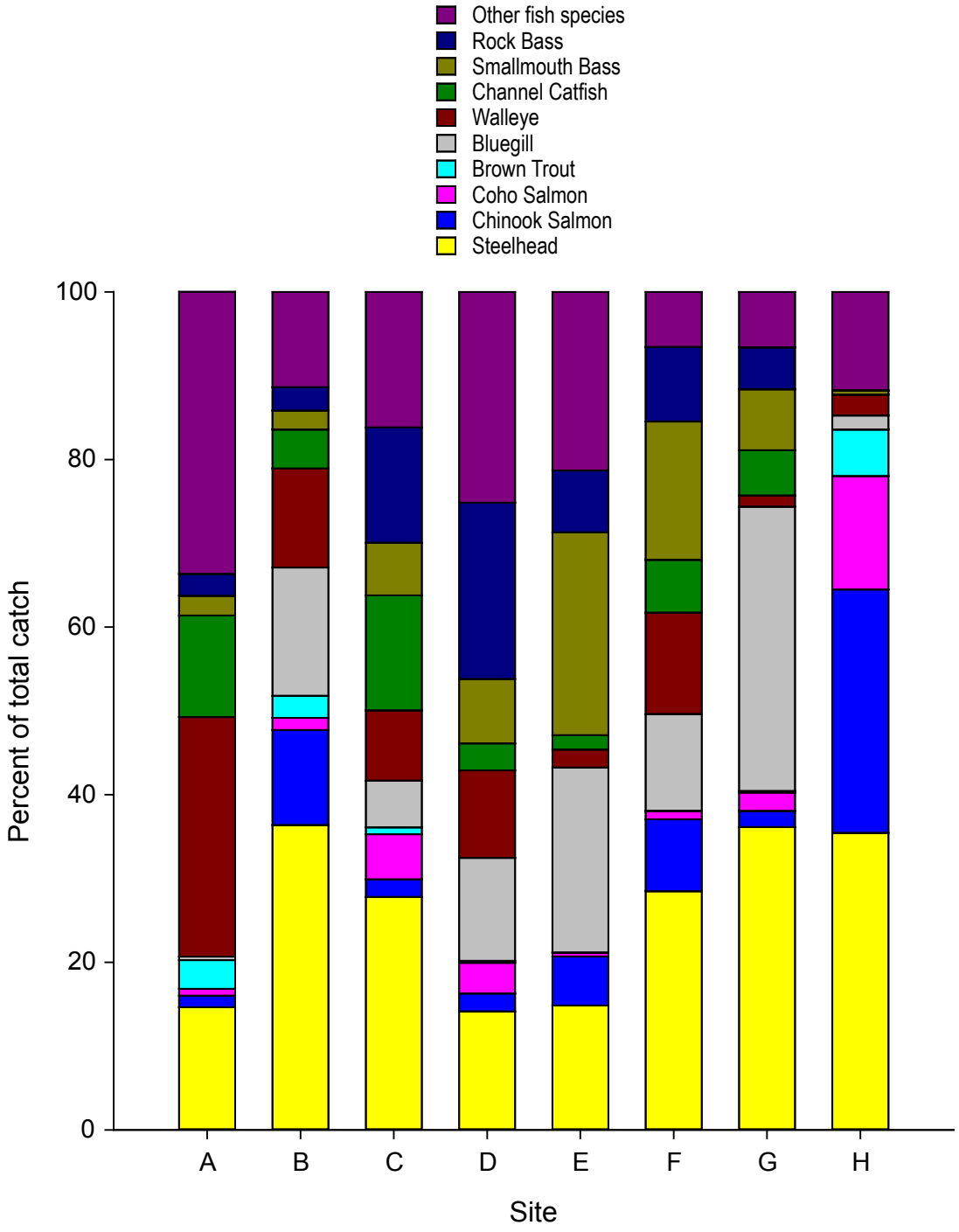


Figure 10.–Species composition of the harvest at each creel survey site on the St. Joseph and Dowagiac rivers during 1992–2004. See Figure 1 for site locations.

Catch and Harvest Rates

During 1992–2004, the harvest per angler hour (HPH) for all species at all sites was 0.1165 (Table 6). The HPH estimates for individual sites on the St. Joseph River were similar, ranging from 0.1043 between the Berrien Springs and Buchanan dams (site C) to 0.1386 downstream of the Twin Branch Dam (site G). The HPH on the Dowagiac River, where the fishery was heavily dependent upon runs of potamodromous salmonids, was substantially lower (0.0588).

Catch per angler hour (CPH) estimates, which include harvested and released fish, also were calculated for salmonids and Smallmouth Bass. For these species, CPH provides a more accurate representation of the fishery than HPH. Substantial numbers of these fish were released by anglers, and the ratio of released fish to harvested fish changed during the study period (see Catch-and-Release).

Steelhead were an important component of the fisheries at all sites. The highest CPH estimates for steelhead were documented in the Dowagiac River (0.0834) and between the Berrien Springs and Buchanan dams (site C, 0.0832; Figure 11). Steelhead CPHs at the St. Joseph River and Dowagiac River creel stations generally were higher than those observed in the Manistee River during 1999–2004 (Figure 12). Rainbow Trout CPHs in the Muskegon River were higher than those observed in the St. Joseph and Dowagiac rivers, but the Muskegon River catch included a mixture of steelhead and resident Rainbow Trout. Steelhead CPH in the St. Joseph and Dowagiac rivers varied throughout the course of this study, but there was no long-term pattern of increasing or declining catch rates (Figure 13).

The Dowagiac River (site H) had the highest CPHs for Chinook (0.0478) and Coho (0.0146) Salmon (Figure 11). Within the St. Joseph River main stem, Chinook Salmon catch rates were highest between the state line and the South Bend Dam (site E), and Coho Salmon CPH was highest between the Berrien Springs and Buchanan dams (site C). Chinook Salmon CPH in the Dowagiac River was similar to that observed in the Muskegon River, but lower than recorded for the Manistee River (Figure 12). Coho Salmon catch rates at multiple sites within the St. Joseph River system were higher than those observed on the Manistee River.

Apart from a period of unusually high catch rates during 1999–2000, Chinook Salmon CPH was relatively stable throughout the study period (Figure 13). Catch rates for Coho Salmon were higher during 1997–2004 than during 1993–1996. Temporal variation in CPH also was more pronounced for Coho Salmon than for other salmonid species (Figure 13). The highest CPH for Coho Salmon was more than 100 times greater than the lowest catch rate for this species.

For Brown Trout, the highest CPH estimates were obtained downstream of the Berrien Springs Dam (sites A and B) and in the Dowagiac River (site H; Figure 11). Few Brown Trout were caught in the Indiana portion of the river. Although there was some annual variation in CPH, there was no clear temporal trend in Brown Trout catch rates (Figure 13).

Smallmouth Bass CPH was highest between the state line and the South Bend Dam (site E; Figure 14). Within the Michigan portion of the river, catch rates were highest between the Berrien Springs and Niles dams (sites C and D). Few Smallmouth Bass were caught in the Dowagiac River.

The Walleye HPH downstream of the Jasper Dairy DNR boat launch site (site A; 0.0348) was more than twice the harvest rate observed at any of the other sites (Figure 14). In general, the Walleye HPH was greater in the Michigan portion of the St. Joseph River, but harvest rates were relatively high between the South Bend and Mishawaka dams (site F). Bluegill HPH was greatest between the Mishawaka and Twin Branch dams (site G), whereas Channel Catfish HPH was highest downstream of the Jasper Dairy DNR boat launch site (site A).

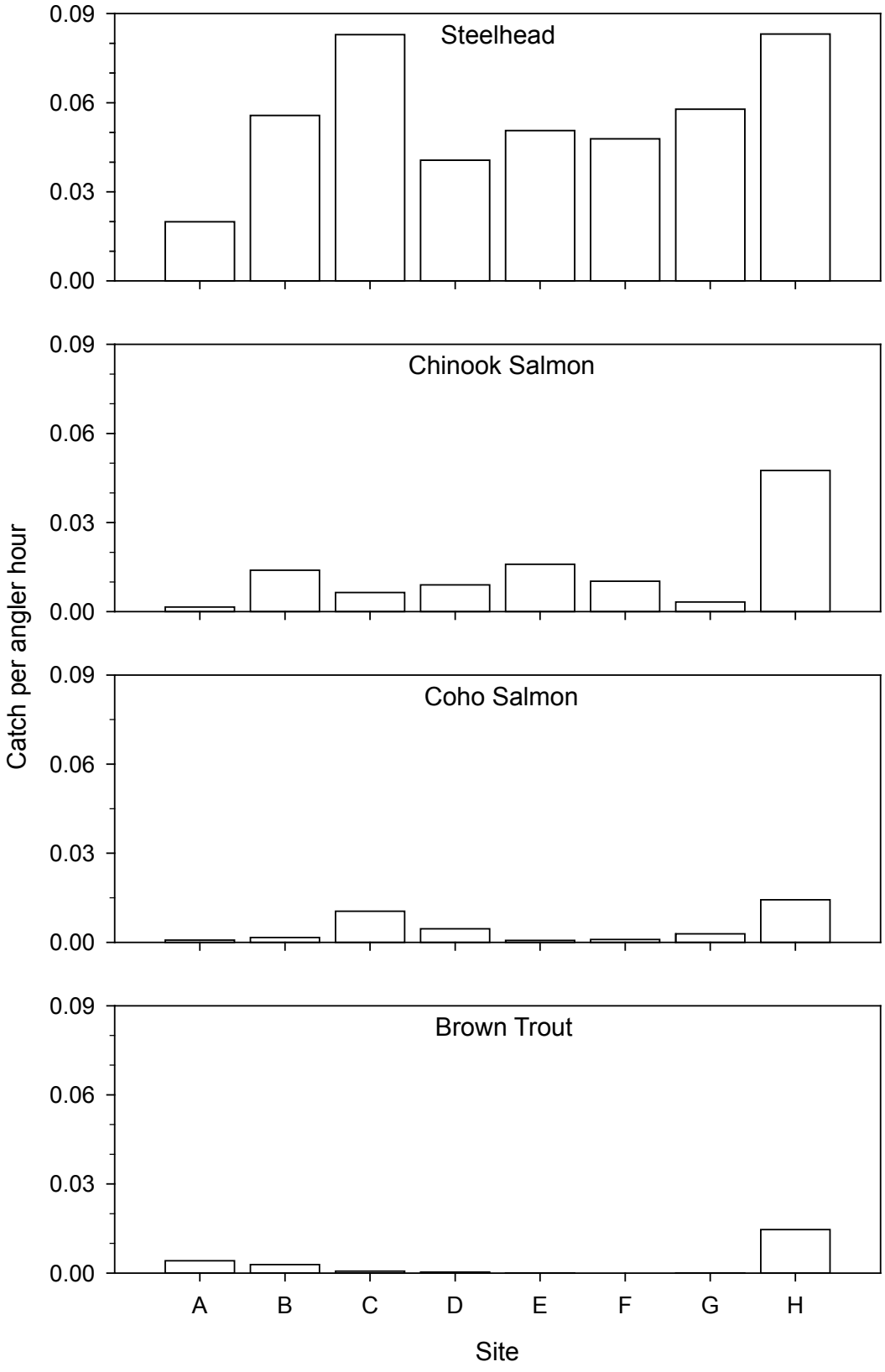


Figure 11.–Catch (harvest plus release) per angler hour estimates for salmonids in the St. Joseph and Dowagiac rivers, 1992–2004. The Brown Trout catch per angler hour for site F was less than 0.0001 fish/hr. See Figure 1 for site locations.

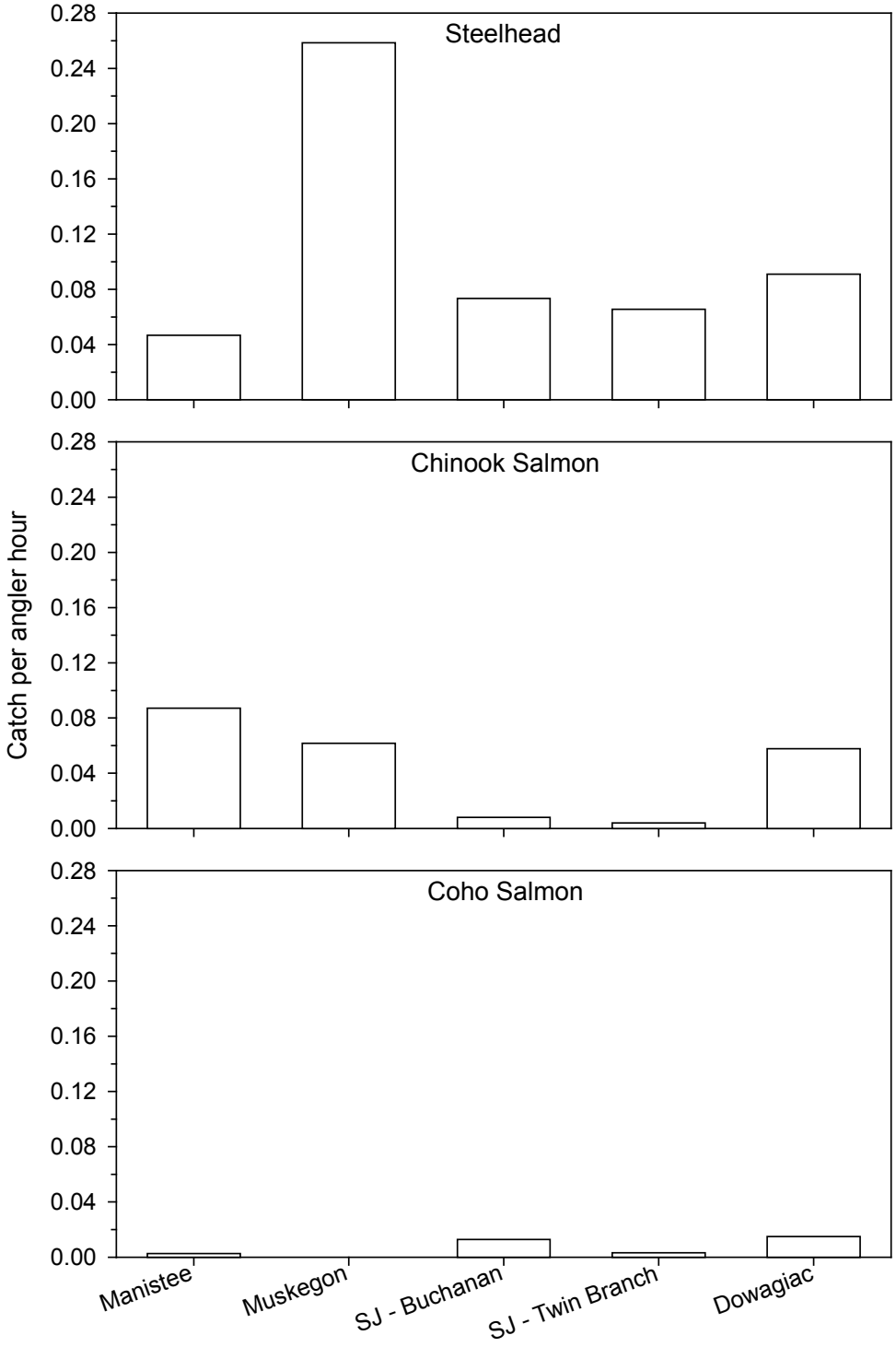


Figure 12.–Catch (harvest plus release) per angler hour of steelhead, Chinook Salmon, and Coho Salmon in the Manistee, Muskegon, St. Joseph, and Dowagiac rivers, 1999–2004 (Zhenming Su, MDNR Fisheries Division, unpublished). No Coho Salmon were caught in the Muskegon River. Manistee = Manistee River between Bear Creek and Tippy Dam, Muskegon = Muskegon River between the Newaygo public access site and Croton Dam, SJ – Buchanan = St. Joseph River between the Berrien Springs and Buchanan dams (site C), SJ – Twin Branch = St. Joseph River between the Mishawaka and Twin Branch dams (site G), and Dowagiac = Dowagiac River from Pucker Street Dam to the confluence with the St. Joseph River (site H).

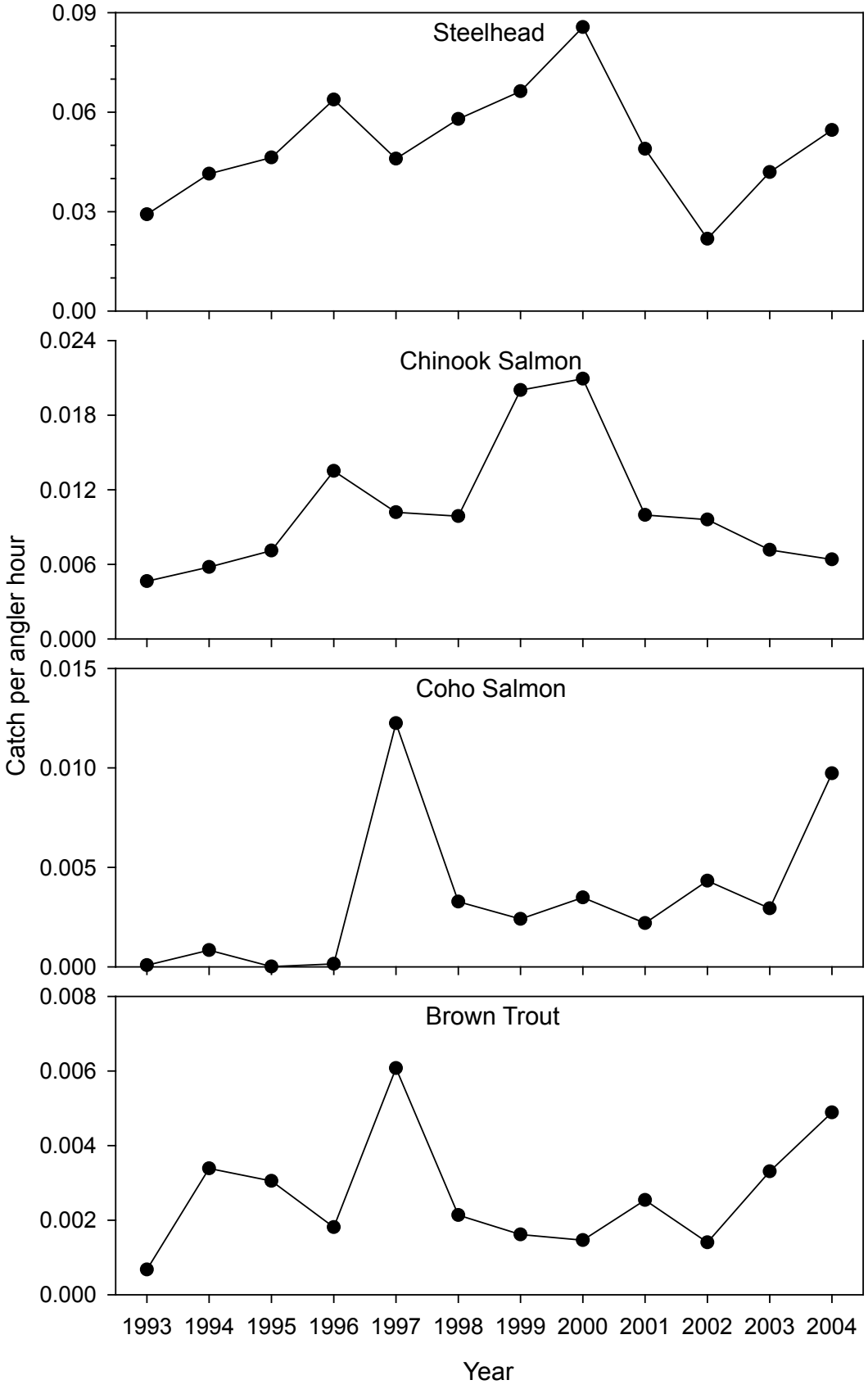


Figure 13.–Annual catch (harvest plus release) per angler hour estimates for all creel survey sites on the St. Joseph and Dowagiac rivers, 1993–2004.

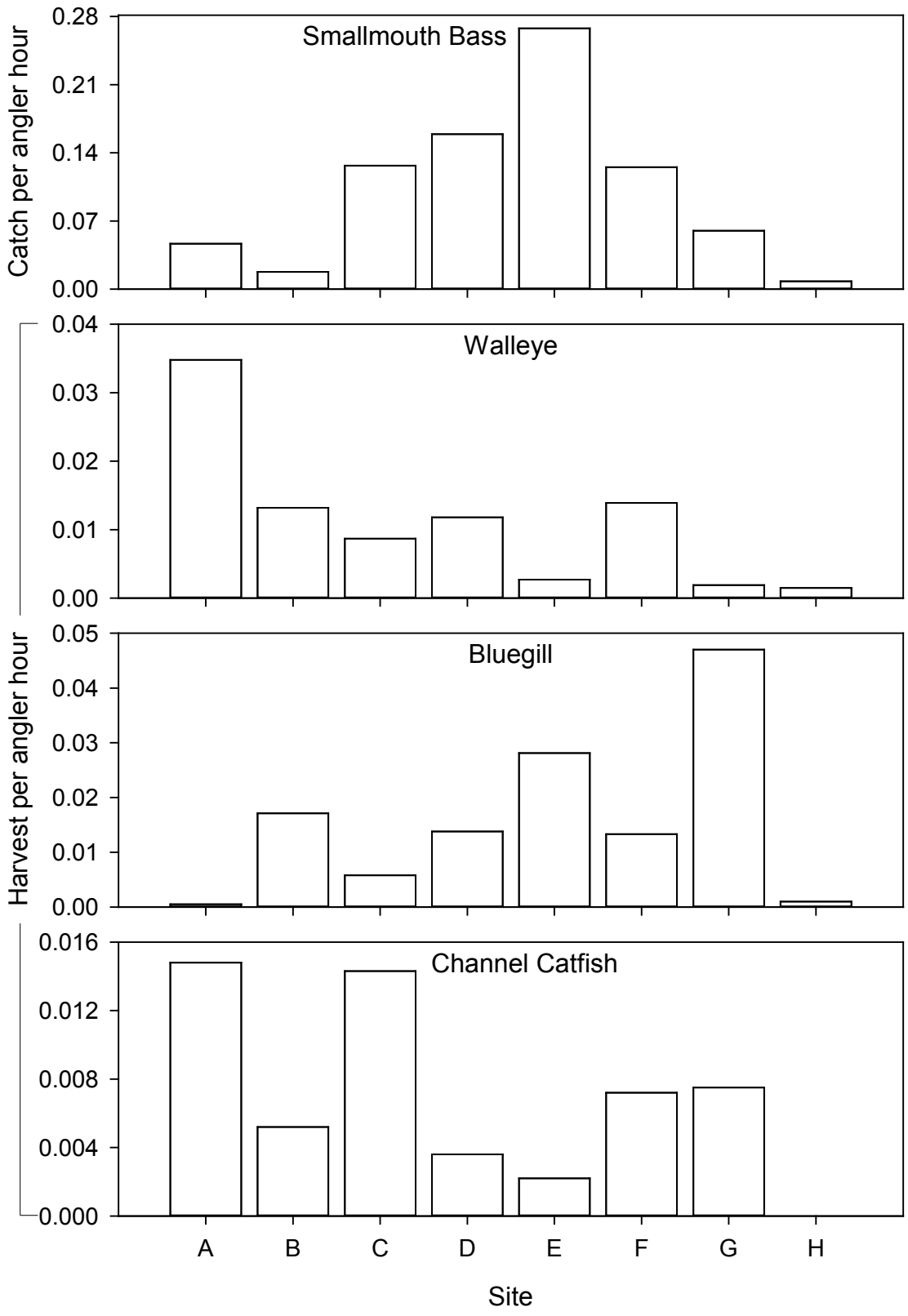


Figure 14.–Catch (harvest plus release) per angler hour estimates for Smallmouth Bass and harvest per angler hour estimates for other game fish species in the St. Joseph and Dowagiac rivers, 1992–2004. See Figure 1 for site locations.

Catch-and-release

Catch-and-release of steelhead increased during the course of this study (Figure 15). The percentage of steelhead released varied by sampling site. Relatively high percentages of steelhead were released in the Dowagiac River (site H) and in the St. Joseph River between the Berrien Springs and South Bend dams (sites C–E; Figure 16); at these sites, more steelhead were released than harvested. By contrast, most of the steelhead caught downstream of the Berrien Springs Dam or between the South Bend and Twin Branch dams were harvested. The percentage of steelhead released also varied by season. Steelhead captured in the fall were much more likely to be harvested than fish captured in the spring or summer (Figure 17). Catch-and-release of other salmonids also increased during the study period (Figure 18), and the geographic patterns in catch-and-release for salmon and Brown Trout were similar to that observed for steelhead (Figures 19 and 16).

Catch-and-release of Smallmouth Bass remained relatively stable throughout the duration of the study (Figure 18). Legal-size Smallmouth Bass were more likely to be released than were adult salmonids. The geographic pattern for catch-and-release of Smallmouth Bass also differed from that observed for salmonids (Figure 19). The percentage of Smallmouth Bass released was greater in Michigan than in the Indiana portion of the river.

Steelhead Seasonal Catch Patterns

For the entire study area, approximately 48% of the steelhead catch occurred during the fall, compared to 32% in the spring and 19% in the summer. Among the different creel survey sites, there was considerable variation in the seasonal distribution of the steelhead catch (Figure 20). At the lowermost site (site A), 79% of the steelhead catch occurred during the fall, with the bulk of the steelhead caught during November–December. Upstream of the Jasper Dairy DNR boat launch site (site B), more steelhead were caught in spring and summer (compared to site A); however, fall captures still accounted for 54% of the total catch. The Berrien Springs to Buchanan station (site C) was unique. Seventy-three percent of the catch at site C occurred during the summer, with only 16% occurring during the fall. Between the Buchanan and South Bend dams (sites D and E), the majority of the steelhead catch occurred during the spring. Upstream of South Bend Dam (sites F and G), 64% of the catch occurred during the fall. For the three Indiana sites combined, only about 7% of the total steelhead catch occurred during June–August. On the Dowagiac River (site H), the steelhead catch was more equally distributed throughout the seasons. Approximately 43%, 21%, and 36% occurred in the spring, summer, and fall, respectively.

Fish Passage and Catch

There appeared to be a direct correlation between upstream fish passage at the Berrien Springs Dam (data on file) and annual salmonid catch for the study area during 1994–2004 (Figure 21). Significant correlations were observed for steelhead ($r_s = 0.71$; $p = 0.015$), Chinook Salmon ($r_s = 0.65$; $p = 0.032$), and Coho Salmon ($r_s = 0.75$; $p = 0.008$). Although catch of Brown Trout generally increased with increasing fish passage, there was substantial variability in the ratio of catch to observed fish passage ($r_s = 0.55$; $p = 0.083$).

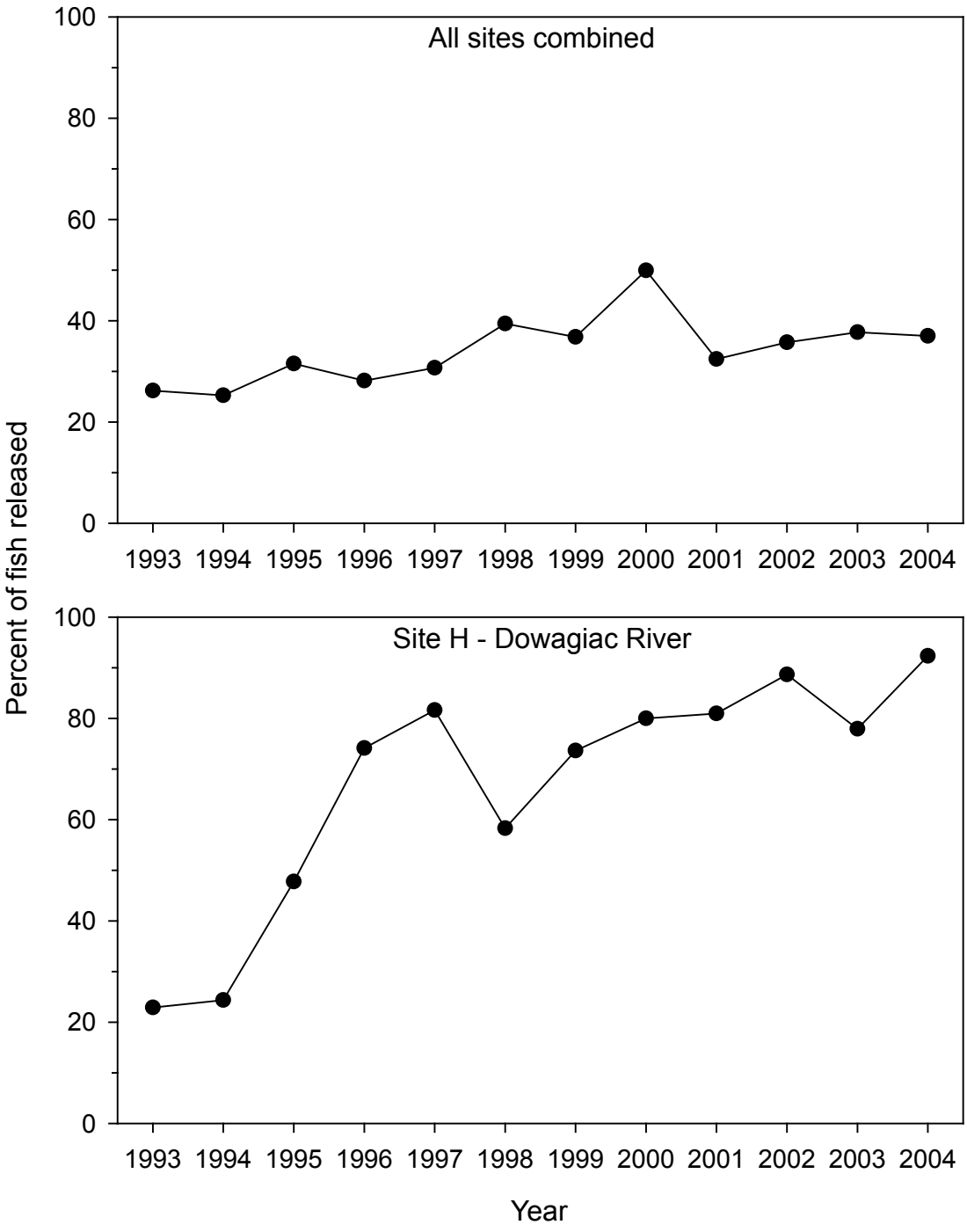


Figure 15.–Annual estimates of the percentage of legal-size steelhead released at (A) all creel survey sites on the St. Joseph and Dowagiac rivers and (B) in the Dowagiac River downstream of the Pucker Street Dam, 1993–2004.

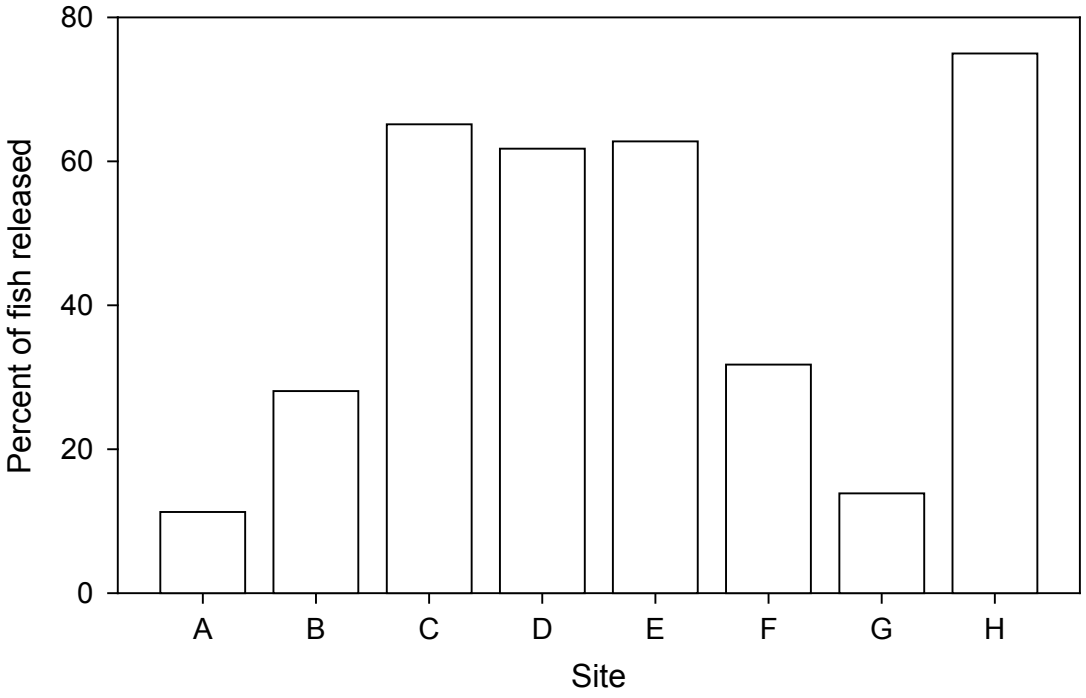


Figure 16.–Percentage of legal-size steelhead released at each creel survey site on the St. Joseph and Dowagiac rivers, 1993–2004. See Figure 1 for site locations.

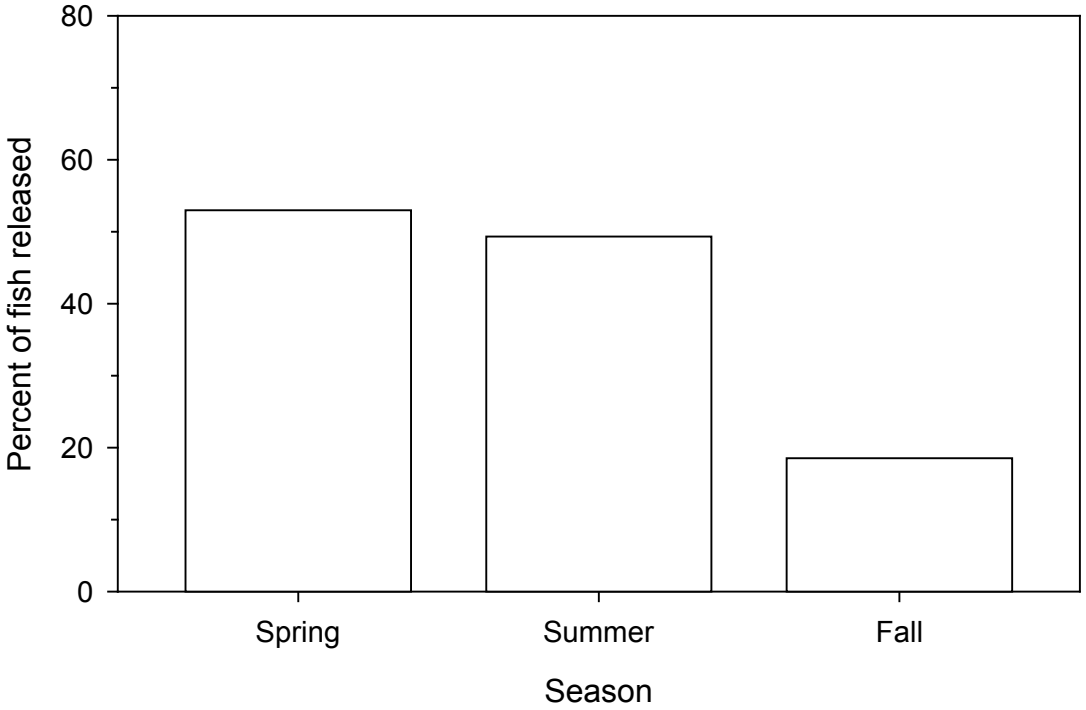


Figure 17.–Percentage of legal-size steelhead released by season for all creel survey sites on the St. Joseph and Dowagiac rivers, 1993–2004. Spring = March-April, summer = June–August, and fall = September-December.

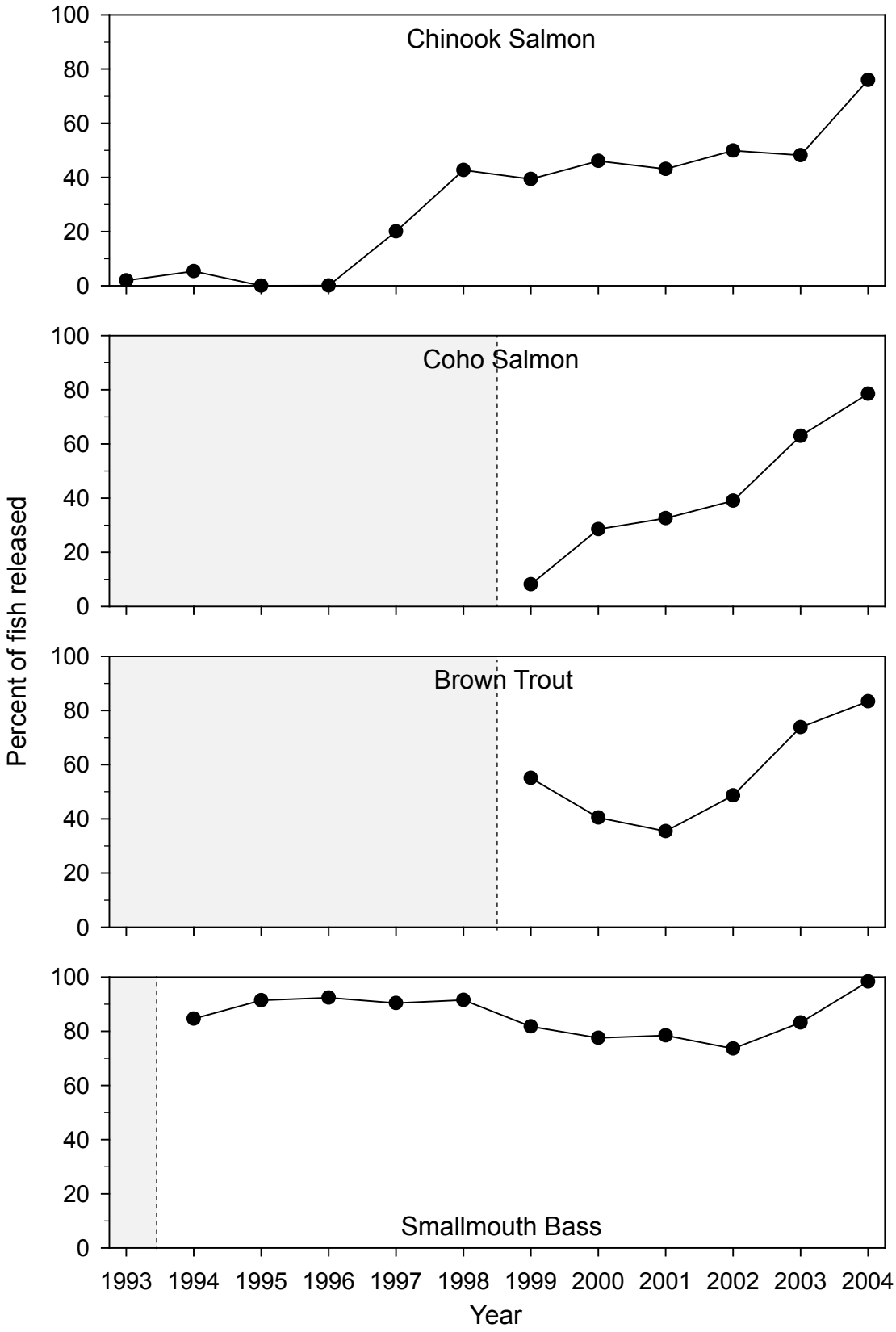


Figure 18.–Annual estimates of the percentage of legal-size fish released at all creel survey sites on the St. Joseph and Dowagiac rivers, 1993–2004. Shaded areas indicate no data for released fish.

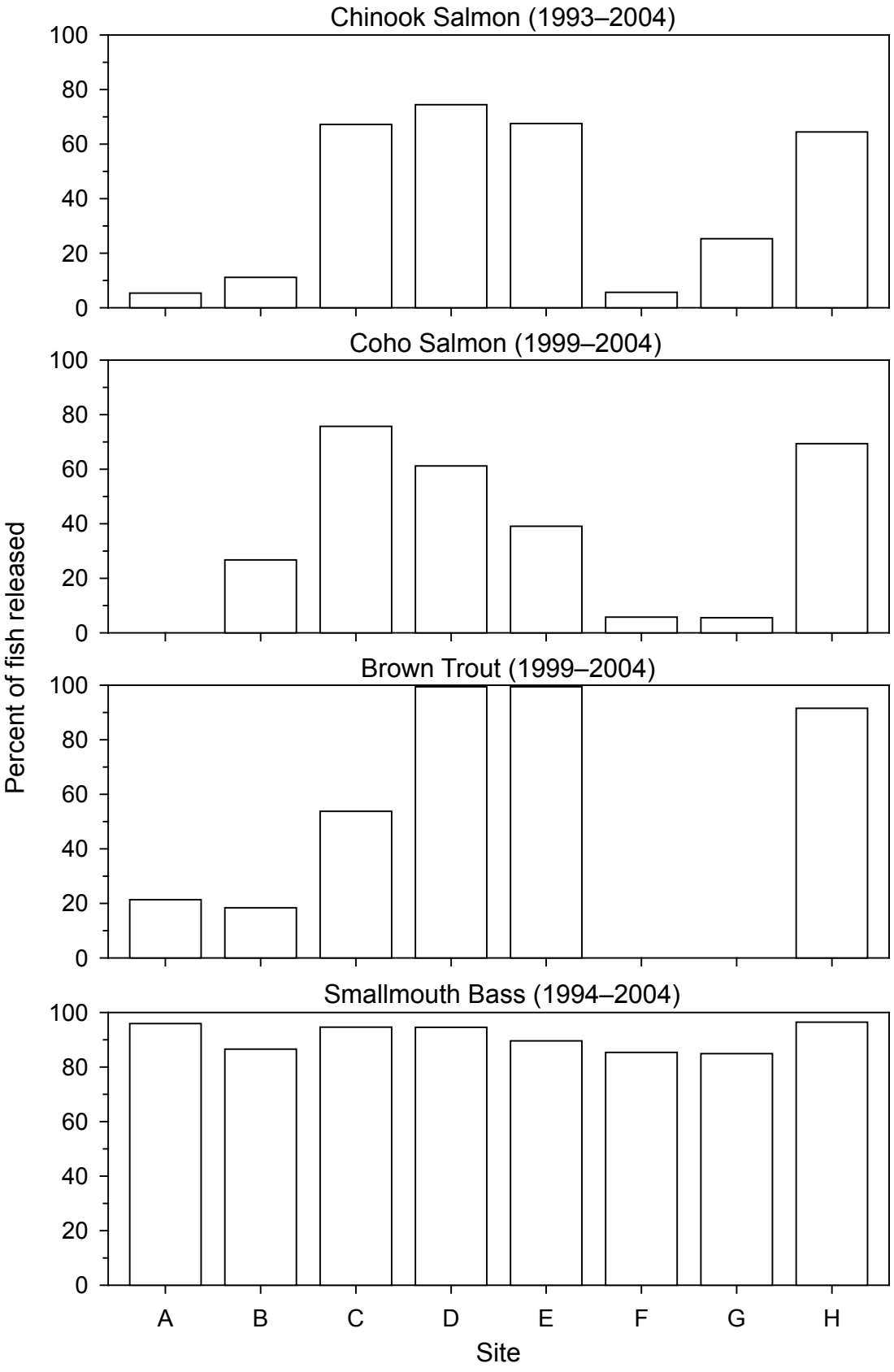


Figure 19.–Percentage of legal-size fish released at each creel survey site on the St. Joseph and Dowagiac rivers. None of the anglers interviewed at sites F and G had released a Brown Trout. See Figure 1 for site locations.

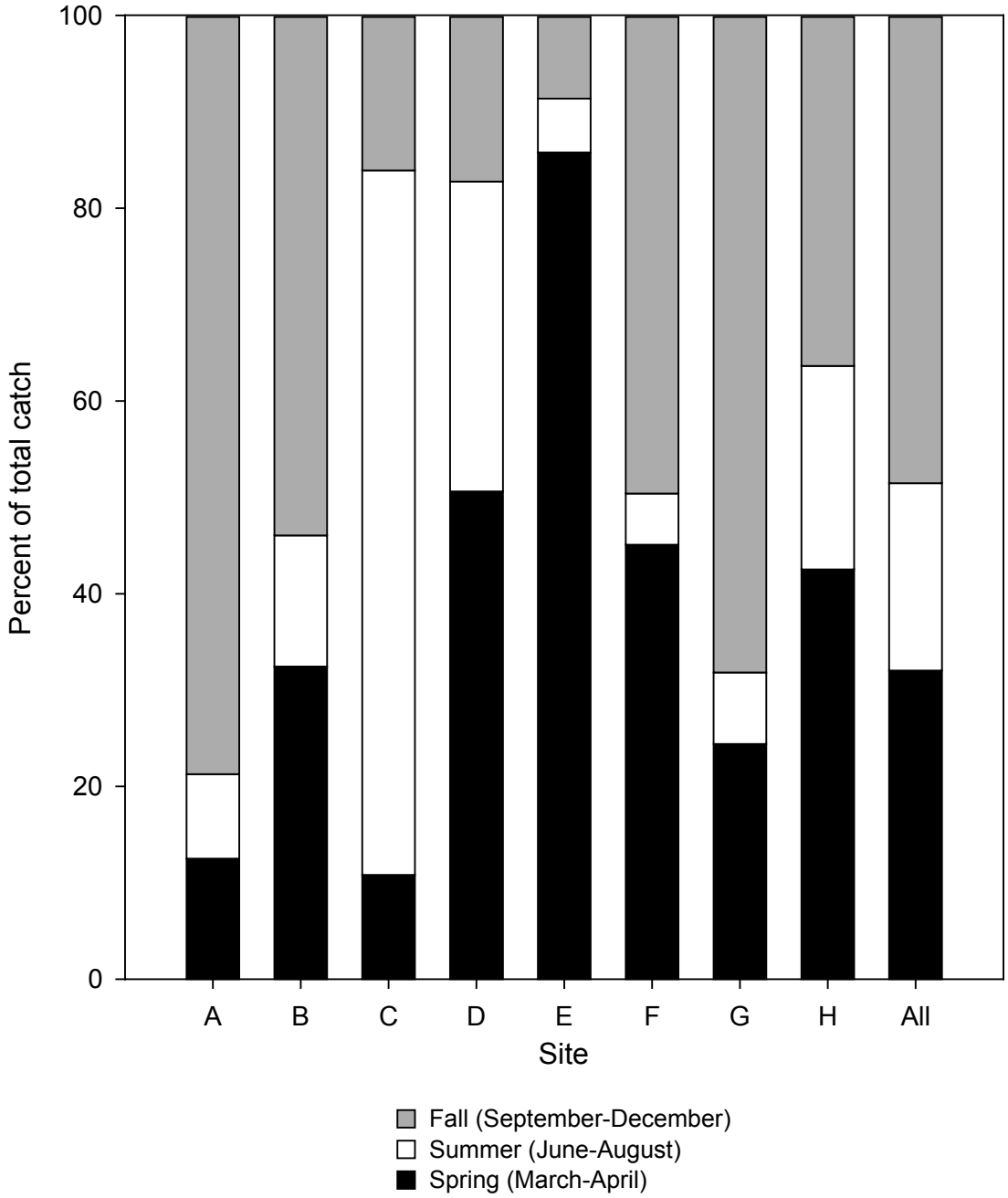


Figure 20.–Seasonal distribution of the steelhead catch (harvest plus release) at each creel survey site on the St. Joseph and Dowagiac rivers, 1993–2004. See Figure 2 for site locations.

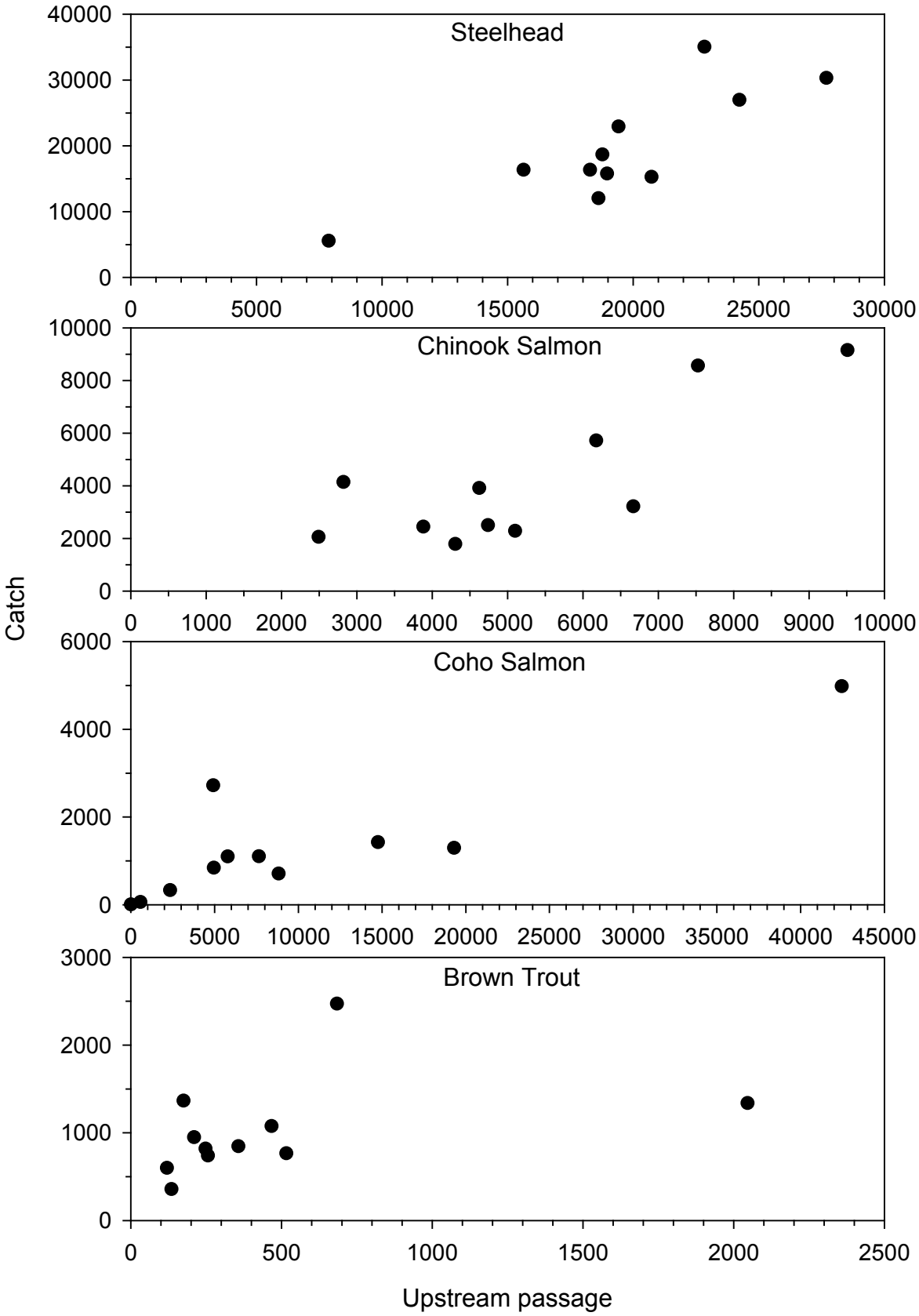


Figure 21.–Annual upstream fish passage at Berrien Springs Dam (MDNR files) versus annual catch (harvest plus release) for all creel survey locations in the St. Joseph and Dowagiac rivers, 1994–2004.

Cost-benefit Analyses

Construction of the fish ladders in the St. Joseph River cost $14.84 million (Table 7). Construction of the Richard Clay Bodine State Fish Hatchery cost $2.69 million. Thus, the total initial capital investment for the St. Joseph River project was $17.53 million.

During 1997–2004, mean annual fish stocking expenditures were $488,506 for MDNR and $187,207 for IDNR (Table 8). The combined annual fish stocking expenditure for the lower St. Joseph River was $675,713. Most of these expenditures were associated with the Coho Salmon and steelhead stocking programs, as these two species composed 41% and 40% of the annual fishing stocking costs, respectively.

For 2004–2007, the mean annual cost for fish ladder operation was $73,178 for MDNR (Table 9). Staff time (i.e., salaries and benefits) accounted for 82% of the total cost during this period. This included time spent maintaining the Berrien Springs, Buchanan, and Niles fish ladders and time spent assessing fish passage through these ladders. Contractual services, supplies, and materials (CSSM) made up approximately 11% of the total expenditures. During 1998–2003, annual fish ladder operating costs for IDNR ranged from $15,700 to $27,500 with a mean annual cost for IDNR during this period of $20,567.

Total mean annual expenditures (fish stocking costs plus ladder operation costs) for the lower St. Joseph River fishery were $769,458. Mean annual expenditures were $561,684 for MDNR and $207,774 for IDNR. Thus, the expenditure distribution was 73% for MDNR and 27% for IDNR.

During 1997–2004, the mean annual number of angler days was 90,559 for all sites combined. The mean annual benefit associated with this fishing effort was $2,173,404 (Table 10). About 60% of the fishing effort occurred upstream of the Berrien Springs Dam, and the mean annual economic benefit for this region was $1,305,174. The mean annual benefit for the Michigan portion of the study area was $1,383,966 (64% of total), whereas the mean annual benefit for the Indiana portion was $789,438 (36% of total).

Annual targeted effort for salmonids averaged 54,981 angler days during 1997–2004. The mean annual benefit for salmonid fishing was $1,319,544 for all sites combined (Table 11). Fifty-eight percent of this effort occurred upstream of the Berrien Springs Dam, providing an estimated annual benefit of $765,333. The targeted salmonid fisheries in the Michigan and Indiana portions of the study area had annual economic benefits of $846,105 (64%) and $473,439 (36%), respectively.

Annual targeted effort for Walleyes averaged 9,760 angler days during the same period. The mean annual benefit for Walleye fishing was $234,231 (Table 12). Approximately 40% of this effort occurred upstream of the Berrien Springs Dam, providing an estimated annual benefit of $92,592. Most of the Walleye fishing (85%) occurred in the Michigan portion of the study area.

During 1997–2004, the annual number of charter excursions in the lower St. Joseph River varied from 521 to 784 (Table 13). The mean annual number of angler days associated with the charter fishery was 2,459. The estimated annual economic benefit of the charter fishery was $304,885. This is an underestimate, as fishing guides that operated upstream of Berrien Springs Dam and did not have a charter captain's license were not required to provide reports to MDNR.

Table 7.–Construction costs for the St. Joseph River fish ladders and the Richard Clay Bodine State Fish Hatchery. Costs were adjusted to 2006 dollars using the gross domestic product deflator conversion (www.measuringworth.com/uscompare).

Project	Year	Cost	Cost in 2006 dollars
Berrien Springs fish ladder	1975	$692,500	$2,130,000
Berrien Springs fish ladder modifications	1992	$450,000	$607,000
Buchanan fish ladder	1990	$2,945,670	$4,210,000
Buchanan fish ladder modifications	1992	$83,600	$113,000
Niles fish ladder	1991	$2,452,500	$3,390,000
South Bend fish ladder [a]	1988	$1,100,000	$1,700,000
Mishawaka fish ladder	1991	$1,400,000	$2,690,000
Richard Clay Bodine Fish Hatchery	1983	$1,500,000	$2,690,000
Total			$17,530,000

[a] Does not include costs for development of demonstration hydroelectric facility.

Table 8.–Mean annual fish stocking costs for the lower St. Joseph and Dowagiac rivers, 1997–2004. Costs-per-fish were converted to 2006 dollars using the consumer price index conversion (www.measuringworth.com/uscompare).

Species	Number	Life stage	Cost/fish	Annual cost (2006 dollars)
Michigan				
Chinook Salmon	229,858	Spring fingerling	$0.26	$59,763
Brown Trout	27,257	Yearling	$1.21	$32,981
Rainbow Trout (Michigan strain)	75,275	Yearling	$1.32	$99,363
Rainbow Trout (Skamania strain)	16,995	Yearling	$0.63	$10,707
Coho Salmon	133,516	Yearling	$1.87	$249,675
Coho Salmon	65,003	Fall fingerling	$0.42	$27,301
Walleye	96,840	Spring fingerling	$0.09	$8,716
Michigan total				$488,506
Indiana				
Rainbow Trout (Michigan strain)	14,933	Yearling	$1.32	$19,712
Rainbow Trout (Skamania strain)	168,042	Yearling	$0.63	$105,866
Rainbow Trout (Skamania strain)	77,136	Fall fingerling	$0.46	$35,483
Chinook Salmon	100,561	Spring fingerling	$0.26	$26,146
Indiana total				$187,207
Combined total				$675,713

Table 9.–Annual MDNR costs in 2006 dollars for salaries, transportation, contractual services, supplies, and materials for the St. Joseph River fish ladders during 2004-2007. Salaries were calculated by multiplying wages by 1.45 to account for benefits. Salary costs were converted to 2006 dollars using the unskilled wage indicator, whereas transportation and contractual services, supplies, and materials (CSSM) costs were converted to 2006 dollars using the consumer price index conversion (www.measuringworth.com/uscompare).

Expenditure	Year				Average
	2004	2005	2006	2007	
Salaries	$52,300	$60,600	$71,081	$57,400	$60,345
Transportation	$1,170	$4,690	$7,298	$7,180	$5,085
Contractual services/ supplies/materials	$7,930	$9,630	$10,704	$2,730	$7,749
Total	$61,400	$74,920	$89,083	$67,310	$73,178

Table 10.–Angler days and associated economic benefits for the St. Joseph and Dowagiac rivers during 1997–2004. The estimated economic benefit was $24 per angler day in 2006 dollars (United States Department of the Interior et al. 2008b). See Figure 2 for site locations.

Site	Total angler days	Mean annual angler days	Total benefit	Mean annual benefit	% of total benefit
A	84,738	10,592	$2,033,712	$254,214	11.7
B	204,672	25,584	$4,912,128	$614,016	28.3
C	60,371	7,546	$1,448,904	$181,113	8.3
D	59,854	7,482	$1,436,496	$179,562	8.3
E	46,807	5,851	$1,123,368	$140,421	6.5
F	70,618	8,827	$1,694,832	$211,854	9.7
G	145,721	18,215	$3,497,304	$437,163	20.1
H	51,687	6,461	$1,240,488	$155,061	7.1
All sites			$17,387,232	$2,173,404	
Upstream of Berrien Springs Dam			$10,441,392	$1,305,174	60.1
Downstream of Berrien Springs Dam			$6,945,840	$868,230	39.9
Michigan sites			$11,071,728	$1,383,966	63.7
Indiana sites			$6,315,504	$789,438	36.3

Table 11.–Targeted fishing effort (angler days) for salmonids and associated economic benefits for the St. Joseph and Dowagiac rivers during 1997–2004. The estimated economic benefit was $24 per angler day in 2006 dollars (United States Department of the Interior et al. 2008b). See Figure 2 for site locations.

Site	Total angler days	Mean annual angler days	Total benefit	Mean annual benefit	% of total benefit
A	27,433	3,429	$658,392	$82,296	6.2
B	157,304	19,663	$3,775,296	$471,912	35.8
C	26,392	3,299	$633,408	$79,176	6.0
D	23,311	2,914	$559,464	$69,936	5.3
E	20,946	2,618	$502,704	$62,832	4.8
F	31,831	3,979	$763,944	$95,496	7.2
G	105,036	13,129	$2,520,864	$315,096	23.9
H	47,595	5,949	$1,142,280	$142,776	10.8
All sites			$10,556,352	$1,319,544	
Upstream of Berrien Springs Dam			$6,122,664	$765,333	58.0
Downstream of Berrien Springs Dam			$4,433,688	$554,211	42.0
Michigan sites			$6,768,840	$846,105	64.1
Indiana sites			$3,787,512	$473,439	35.9

Table 12.–Targeted fishing effort (angler days) for Walleye and associated economic benefits for the St. Joseph and Dowagiac rivers during 1997-2004. The estimated economic benefit was $24 per angler day in 2006 dollars (United States Department of the Interior et al. 2008b). See Figure 2 for site locations.

Site	Total angler days	Mean annual angler days	Total benefit	Mean annual benefit	% of total benefit
A	28,735	3,592	$689,640	$86,205	36.8
B	18,478	2,310	$443,472	$55,434	23.7
C	9,645	1,206	$231,480	$28,935	12.4
D	9,528	1,191	$228,672	$28,584	12.2
E	1,200	150	$28,800	$3,600	1.5
F	8,704	1,088	$208,896	$26,112	11.1
G	1,588	198	$38,112	$4,764	2.0
H	199	25	$4,776	$597	0.3
All sites			$1,873,848	$234,231	
Upstream of Berrien Springs Dam			$740,736	$92,592	39.5
Downstream of Berrien Springs Dam			$1,133,112	$141,639	60.5
Michigan sites			$1,598,040	$199,755	85.3
Indiana sites			$275,808	$34,476	14.7

Table 13.–Charter fishing excursions, client angler days, and associated economic benefits for the St. Joseph River during 1997-2004. Most charter excursions occurred downstream of Buchanan Dam (sites A-C in Figure 2). The estimated economic benefit was $124 per angler day in 2006 dollars (United States Department of the Interior et al. 2008b).

Year	Excursions	Angler Days	Benefits
1997	670	2,595	$321,780
1998	754	2,872	$356,128
1999	779	2,997	$371,628
2000	784	3,154	$391,096
2001	601	2,198	$272,552
2002	537	1,980	$245,520
2003	527	1,907	$236,468
2004	521	1,967	$243,908
Total benefit			$2,439,080
Mean annual benefit			$304,885

Discussion

Effort

For the open water fishing season (i.e., winter excluded), fishing effort was greatest in the fall and lowest in the spring. Fishing regulations and seasonal changes in the fish community probably were responsible for the observed pattern. During March–April, most warmwater species are relatively inactive, and the possession season is closed for some species (e.g., Smallmouth Bass and Walleye). Rainbow Trout and White Suckers were the primary species targeted by anglers during the spring. Cool air temperatures and high flows may also have contributed to reduced fishing effort during this period. Fishing effort increased as water temperatures rose and warmwater fish species became active during the summer months. Effort peaked in the fall as salmon and steelhead moved into the river.

During spring and fall, fishing effort was concentrated at sites B and G. Migratory salmonids tend to congregate in these areas as the Berrien Springs Dam is the first barrier and the Twin Branch Dam is the final and impassable barrier to fish movement in the lower St. Joseph River. Fishing effort was more evenly distributed in the summer when anglers were targeting a wide variety of warmwater species.

One of the objectives for the fish ladder project was to determine if even this low level and likely insufficient amount of constructed fish passage would provide increased fishing opportunities near the urban centers of South Bend and Mishawaka. The fish ladders and associated stocking programs appear to have accomplished this objective. For September–October, fishing effort was substantially higher at the three Indiana sites during 1992–2005 than during 1985–1986 (Figure 6). Prior to construction of the fish ladders, salmonids were not present in this portion of the river. After fish ladder construction, about 45% of the effort at sites E and F and 72% of the effort at site G was directed toward salmonids (Table 5).

Fishing pressure decreased downstream of the Berrien Springs Dam (sites A and B) after the fish ladders were constructed. This decrease apparently was not caused by Michigan anglers shifting

their fishing effort to the Indiana portion of the river, as few out-of-state anglers were encountered at sites E–G. However, it is probable that many Indiana anglers stopped driving to Berrien Springs once steelhead and salmon were able to move upstream to South Bend and Mishawaka.

Sufficient pretreatment data are not available to rigorously evaluate the effects of fish ladder construction on fishing effort between the Berrien Springs and Niles dams. Prior to fish ladder construction (Berrien Springs in 1975 and Buchanan in 1990), salmonids were essentially absent from this portion of the river. Small numbers of Brown Trout probably entered the St. Joseph River from tributary streams, but it is unlikely that any anglers targeted trout in the main stem. During 1997–2004, 44% and 39% of the fishing effort was directed towards salmonids at sites C and D, respectively, so it appears likely that fish ladder construction increased fishing pressure in this portion of the river.

Although no pretreatment data are available for the Dowagiac River (site H), it is likely that fish ladder construction also increased fishing effort on this stream reach. Steelhead and salmon composed the bulk of the harvest during the creel surveys, whereas resident Brown Trout were the only salmonids present prior to fish ladder construction. During the last 20 years, the Dowagiac River has earned a reputation as one of the best salmon and steelhead fishing locations in southern Michigan.

The scarcity of pretreatment data makes it difficult to quantify changes in annual fishing effort for the entire study area after the fish ladders were constructed. However, the project clearly did not meet the stated objective of increasing annual fishing effort by 125,000 angler days. During 1997–2004, the mean annual effort for the entire study area was only 90,559 angler days. In hindsight, it appears that this objective of increasing fishing effort by >100% was unrealistic.

During the study period, fishing participation was declining throughout the nation. From 1991 to 2006, the estimated number of anglers in the United States declined by approximately 16% (United States Department of the Interior et al. 1993a; United States Department of the Interior et al. 2007). During this same period, the estimated number of annual angler days in Indiana declined by 25% (United States Department of the Interior et al. 1993b; United States Department of the Interior et al. 2008a). Dann et al. (2008) also reported a 14.5% decline in Michigan fishing license sales during 1995 to 2004. Numerous ecological, economic, and sociological variables affect fishing participation. Thus, while it is relatively easy to predict how fish ladder construction will affect fishing opportunities, it is much more challenging to predict how many anglers will take advantage of those opportunities.

Harvest and Catch Rates

Steelhead are the premier game fish in the St. Joseph River. Steelhead was the top species in terms of harvest at five of the creel survey sites and one of the top three species at the other three sites. In addition, steelhead composed the bulk of the harvest for charter anglers in the lower St. Joseph River during 1997–2004 (www.dnr.state.mi.us/chartercreel).

Jonas et al. (2009) compared returns of Michigan-strain and Skamania-strain steelhead stocked in the St. Joseph River during 1996–1999. Michigan-strain steelhead typically move into the river in late fall or early spring and spawn during March–May, whereas Skamania move into the river as early as late June and spawn during February–March (Seelbach et al. 1994; Dexter and Ledet 1997). For every 10,000 fish stocked, Jonas et al. (2009) found that 14.7 Michigan-strain and 1.6 Skamania-strain steelhead were detected in the St. Joseph River creel surveys. Thus, the estimated return rate to the river fishery was nearly 9 times greater for Michigan-strain than Skamania-strain steelhead. By contrast, the returns to the Lake Michigan fishery were similar for the two strains (Jonas et al. 2009).

One of the rationales for stocking Skamania-strain fish is to create summer fishing opportunities for steelhead. On select stretches of the St. Joseph River system, the stocking program apparently accomplished this objective. About 73% of the steelhead catch between the Berrien Springs and Buchanan dams (site C) occurred during the summer and the mean summer catch was 1,623 fish. The

productivity of the summer steelhead fishery in this stream reach probably is related to the thermal characteristics of the river. During the summer, water temperatures in the lower St. Joseph River can exceed 80°F. Steelhead apparently move into the river when water temperatures are relatively cool (e.g., after a cold rain) and become trapped when water temperatures rise. Multiple coldwater tributaries flow into the St. Joseph River between Berrien Springs and Buchanan, and the mouths of these creeks provide thermal refugia for steelhead. Because steelhead are concentrated in these small refugia, they are highly vulnerable to anglers.

The Dowagiac River (site H) also provides a modest summer fishery for steelhead. Approximately 21% of the steelhead catch at this site occurred during the summer and the mean summer catch was 312 fish. The Dowagiac River is a coldwater stream that provides a thermal refuge for steelhead. Steelhead moving into the Dowagiac River can disperse over three miles of river, whereas the steelhead that remain at the mouths of other tributaries are confined to much smaller areas. Thus, steelhead are not as vulnerable to summer anglers at site H as at site C.

In the Indiana portion of the St. Joseph River, summer steelhead fishing opportunities were limited. Less than 7% of the total steelhead catch occurred during the summer. For sites E–G combined, the mean summer catch was only 428 fish. A variety of factors probably have contributed to the low summer steelhead catch in this part of the river. To reach the state line, steelhead must swim about 48 miles upstream and ascend three fish ladders. This is a difficult journey given that summer water temperatures in the main stem typically are well above the optimum range for this species. Additionally, there are numerous thermal refugia where steelhead could stage in the Michigan portion of the river, whereas thermal refugia are scarce in Indiana waters.

It is important to note that the summer steelhead fishery in the St. Joseph and Dowagiac rivers is not entirely dependent on Skamania-strain fish. Jonas et al. (2009) found that catch rates for Michigan-strain and Skamania-strain steelhead were similar during June–August, but that catch rates were much higher for Michigan-strain fish in the spring and fall. Thus, it is likely that the summer steelhead fishery would persist in the absence of Skamania stocking. If IDNR began stocking Michigan-strain fish instead of Skamania-strain steelhead, the summer catch rates might remain similar whereas the spring and fall catch rates likely would increase.

During the spring and fall, steelhead apparently had little difficulty ascending the fish ladders. Steelhead was the most abundant species moving through each of the ladders (data on file). Furthermore, the harvest per angler hour for steelhead during 1992–2004 was greatest below the Twin Branch Dam (i.e., the most upstream creel survey location).

In terms of catch per angler hour, the St. Joseph River steelhead fishery is comparable to the highly publicized fishery in the Manistee River (Figure 12). Steelhead catch rates in the St. Joseph River also were similar to those recorded for coastal streams in the state of Washington. Spring (March–April) steelhead catch rates were 0.0868 fish/angler hour at site B and 0.1078 fish per angler hour at site G during 1993–2004. Catch rates reported for several coastal streams in Washington during the 2009–2010 steelhead run ranged from 0.0520 fish/angler hour to 0.1622 fish/angler hour (Washington Department of Fish and Wildlife; http://wdfw.wa.gov/fishing/creel/steelhead/2009archive.html).

Catch-and-release fishing for steelhead appeared to be growing in popularity; however, this trend was not uniform across seasons and sampling sites. In general, anglers were more likely to harvest steelhead caught in the fall than fish caught in the spring and summer (Figure 17). One factor that might have affected seasonal harvest patterns was the condition of the fish. Fish caught in the fall were fresh from the lake and were in good condition, whereas many of the fish captured in the spring were in poor condition due to spawning stress. Anglers also may have been releasing fish caught during the spring spawning season to allow them to reproduce. This desire to protect spawning steelhead appears to have been especially popular on the Dowagiac River where anglers could observe the fish on their spawning grounds. The high ratio of released fish/harvested fish during the summer may have been due to demographic factors. Anecdotal information suggests that most people targeting steelhead in the

summer were avid anglers, as opposed to the more even mixture of avid and novice anglers during the spring and fall fisheries. Catch-and-release may be more popular among avid anglers than with anglers who only go fishing a few times per year.

The St. Joseph River supports a modest Chinook Salmon fishery. Much of the salmon fishing effort is concentrated below the Berrien Springs Dam, and 48% of the total catch occurred at site B during 1992–2004. In terms of CPH, the Dowagiac River (site H) had the most productive Chinook salmon fishery. Although there are several coldwater tributaries that provide suitable spawning habitat for steelhead in this system, the Dowagiac River is the only tributary stream that is large enough to attract substantial numbers of salmon.

The St. Joseph River system provides some of the best river Coho Salmon fishing opportunities on the eastern shoreline of Lake Michigan. The change from fall fingerling stocking to yearling stocking probably was responsible for the observed increase in CPH after 1996 (Figure 13). Similarly, the unusually high harvest in 1997 likely can be attributed to an anomaly in the stocking protocol. Between fall fingerling stocking in 1995 and yearling stocking by MDNR and IDNR in 1996, a total of 391,800 fish from the 1995 year class were released into the lower St. Joseph River (Table 1). Coho Salmon typically move into Lake Michigan during the spring of their second year of life, spend 18 months in the lake, then return to their natal stream or stocking location to spawn (Dexter and O'Neal 2004). Thus, the timing of the high Coho Salmon catch in the St. Joseph River coincided with the expected return period for the 1995 year class. In addition, no similar spike was observed for the estimated Coho Salmon harvest for the Michigan waters of Lake Michigan in 1997, which suggests that the abnormal river returns in the St. Joseph River were not tied to a basinwide increase in Coho Salmon abundance (Tracy Kolb, MDNR Fisheries Division, unpublished).

Brown Trout were a minor component of the fishery in the St. Joseph River. Brown Trout return rates have been low throughout Lake Michigan in recent years (Tracy Kolb, MDNR Fisheries Division, unpublished). One potential explanation for the low returns is that the domesticated Brown Trout strains that had been stocked in Lake Michigan were poorly adapted for survival in the wild (Wills 2006). Since the mid-1990s, the predominant Brown Trout strain used for stocking the Michigan waters of the Great Lakes has been the Seeforellen strain. Due to unacceptable performance in the hatcheries and in the wild, the Seeforellen stocking program has been discontinued.

The Brown Trout population in the Dowagiac River (site H) differs from the populations in the St. Joseph River in that it consists of a mixture of resident fish and potamodromous fish from Lake Michigan. Thus, the Dowagiac River provides year-round fishing opportunities for Brown Trout, and the fishery is not entirely dependent on movement of Brown Trout through the fish ladders. The increase in overall Brown Trout catch rates in 2003 and 2004 (Figure 13) was due to increased catch in the Dowagiac River. Seventy-eight percent of the Brown Trout catch during those years occurred at site H.

In terms of number of fish harvested, Bluegill was the most abundant warmwater game species in the lower St. Joseph River. Despite this statistic, only a small percentage of the total fishing effort was directed toward this species. The HPH for Bluegills at all of the sites on the St. Joseph River was substantially lower than the HPHs reported for inland lakes in southwest Michigan where anglers commonly target Bluegills (Gunderman 2010; Zhenming Su, MDNR Fisheries Division, unpublished).

Approximately 78% of the total Walleye harvest during 1992–2004 occurred downstream of the Berrien Springs Dam (sites A and B). There are a variety of explanations for the observed distribution of Walleye in this system.

1. Most of the Walleye stocking has occurred downstream of the Berrien Springs Dam, and no Walleye were stocked between the Niles and Twin Branch dams during the study period; research was recently initiated to evaluate the relative contributions of stocked and naturally-produced fish to the lower St. Joseph River Walleye population, and preliminary results indicate that stocked fish compose a substantial percentage of the overall population.

2. Walleyes rarely moved upstream through the fish ladders that were designed to allow salmonid passage and not designed for Walleye passage, so stocking that occurs downstream of the Berrien Springs Dam does little to supplement the Walleye population in upstream reaches. Only 462 Walleyes moved upstream through the Berrien Springs fish ladder during 1994–2005 (MDNR files).
3. The Walleye population downstream of the Berrien Springs Dam (sites A and B) is supplemented by immigration of fish from Lake Michigan.
4. Seasonal influxes of prey species from Lake Michigan provide a varied and robust forage base for Walleyes, especially at site A.

The Walleye HPH for the entire study area was 0.0129 during 1992–2004. This HPH is close to the median of HPH values recorded for Michigan rivers and similar to Walleye HPHs in the Grand and Kalamazoo rivers (Zhenming Su, MDNR Fisheries Division, unpublished). With the exception of site A, the Walleye HPH at each site in the St. Joseph River was well below the median HPH for large lakes in Michigan (e.g., Hanchin et al. 2008; Hanchin and Kramer 2008a; Hanchin and Kramer 2008b). In 2007, the Walleye HPH in the St. Joseph River upstream of Mottville Dam (0.0237) in St. Joseph County, Michigan, was nearly twice as high as that observed in the present study (Zhenming Su, MDNR Fisheries Division, unpublished). This may reflect a higher percentage of targeted effort for Walleyes, as salmonids are not present in the upper St. Joseph River.

Due to the popularity of catch-and-release fishing, harvest rates do not accurately represent the quality or importance of Smallmouth Bass fisheries. During 1993–2004, anglers released more than eight Smallmouth Bass for every bass that was harvested. The overall Smallmouth Bass catch/angler hour for the study area was 0.0737. This catch rate is in the middle of the values reported for other Michigan waters (e.g., Clark et al. 2004; Hanchin et al. 2005a; Hanchin et al. 2005b) and was higher than those recorded for the lower Grand and Kalamazoo rivers (Zhenming Su, MDNR Fisheries Division, unpublished). Conversely, the Smallmouth Bass catch rate in the St. Joseph River upstream of Mottville Dam during 2007 (0.4323) was much higher than that observed during the present study (Zhenming Su, MDNR Fisheries Division, unpublished).

The creel surveys likely underestimated the importance of the Channel Catfish fishery in the St. Joseph River. Most catfish angling occurs after dark. For safety reasons, evening creel clerk shifts typically were scheduled to end at dusk. Despite this shortcoming, the creel results clearly indicate that Channel Catfish are a major component of the fishery in the lower St. Joseph River. Other fish species provided localized fishing opportunities within the St. Joseph River system. For example, Freshwater Drum were the second most abundant species in the harvest downstream of the Jasper Dairy DNR boat launch site (site A), and Rock Bass composed 17% of the total harvest between the Niles and Berrien Springs dams.

Fish Passage and Catch

Significant correlations were detected between upstream fish passage and annual catch of steelhead and salmon. This pattern was not observed for Brown Trout. During 1994–2004, approximately 67% of the Brown Trout catch occurred downstream of the Berrien Springs Dam (sites A and B), with most of the remainder occurring in the Dowagiac River. For this period, the mean annual Brown Trout catch for all sites was 1,030 fish, whereas mean upstream passage at the Berrien Springs fish ladder was only 474 fish.

A variety of factors probably have contributed to the relatively low passage of Brown Trout through the St. Joseph River fish ladders. Compared to steelhead and salmon, Brown Trout are relatively weak swimmers (Bell 1986; Hotchkiss and Frei 2007). Thus, fish ladders present more of an obstacle to upstream movement for Brown Trout than for steelhead and salmon. Furthermore, steelhead and salmon

life histories typically include long spawning migrations, whereas Brown Trout more commonly travel short distances to their spawning grounds and may reside within a river (e.g., the Dowagiac River) for their entire lives.

Cost-benefit Analysis

The mean annual economic benefit to the surrounding communities for all sites combined was $2,478,289 (including charter and noncharter effort), whereas the mean annual cost for fish ladder operation and fish stocking was $769,458. Thus, the net annual economic benefit from the St. Joseph and Dowagiac river fisheries was $1,708,831. With a net annual benefit of $1.7 million, it would take about 10 years to recoup the initial $17.53 million investment in fish ladder and hatchery construction that should be noted was a test of fishway designs in the Midwest and not complete mitigation for the fragmentation of this river system by these dams (Table 7). Not all of the fishing effort on the St. Joseph River can be attributed to fish ladder construction, so these estimates are overly optimistic.

Because pre-ladder construction creel survey data are lacking for most of the study area, it was not possible to quantify the increase in fishing effort after ladder construction. One way to evaluate the effects of fish ladder construction on effort is to examine the targeted effort for salmonids upstream of the Berrien Springs Dam. With the exception of the resident Brown Trout fishery in the Dowagiac River (site H), there would be no salmonid fishing effort in these stream reaches without the fish ladders. For the six creel survey sites upstream of the Berrien Springs Dam, the mean annual economic benefit for the salmonid fishery was $765,333 (Table 11). This yields an estimated net benefit of only $4,591 (Walleye stocking costs excluded). However, if stocking costs for salmonids stocked downstream of Berrien Springs Dam are omitted (which may have been stocked in the absence of the ladders), then the net annual benefit for the salmonid fishery upstream of the Berrien Springs Dam was $765,333 – $331,212 = $434,121. With this estimate, the initial investment would be repaid in approximately 40 years.

For the Michigan portion of the study area, the mean annual economic benefit from the fishery was $1,688,851 (including charter and noncharter effort), and the mean annual cost was $561,684. Thus, the lower St. Joseph River fishery (sites A–D and site H) yielded a net economic benefit of $1,127,167. However, much of the fishing effort in the Michigan portion of the river occurs downstream of the Berrien Springs Dam (sites A and B). This lower section of the river would have supported salmonid fisheries even in the absence of the fish ladders. Therefore, a more important concern was the net economic benefit for the salmonid fisheries upstream of the Berrien Springs Dam. If stocking costs for fish stocked downstream of the Berrien Springs Dam are excluded, the mean annual net economic benefit for the salmonid fisheries at sites C, D, and H was $168,450. Using this figure, it would take 62 years to recoup the money spent to construct and modify the Berrien Springs, Buchanan, and Niles fish ladders.

For the Indiana portion of the study area, the mean annual economic benefit was $789,438, the mean annual cost was $207,774, and the net annual benefit was $581,664. Essentially all of the costs and all of the benefits are associated with the salmonid fishery. The mean annual benefit from the salmonid fishery was $473,439, yielding a net annual benefit of $265,665. With this net benefit, it would take approximately 27 years for Indiana to recoup the initial investment of $7.08 million for construction of the South Bend and Mishawaka fish ladders and the Richard Clay Bodine Fish Hatchery.

As with any large-scale economic analysis, there were caveats to the information presented in this report. For the purposes of this analysis, it was assumed that all of the economic benefits associated with fishing effort at each creel survey site were received by the businesses within that geographic area. For example, all of the fishing-related expenditures for angler days in the Michigan portion of the study area were assumed to occur in Michigan. Some of the fishing expenditures likely occurred outside

of the study area (e.g., fishing tackle and fuel purchases), but it was not possible to determine what percentage of fishing expenditures occurred within versus outside the area of interest.

Calculations based solely on fishing effort in the St. Joseph River underestimate the actual economic benefit of the stocking programs and fish ladder operation. Salmonids stocked in the St. Joseph and Dowagiac rivers also create fishing opportunities in Lake Michigan. For example, Jonas et al. (2009) found that steelhead stocked in the St. Joseph River were recaptured as far north as Grand Traverse Bay. In addition, natural reproduction of steelhead (and, to a lesser extent, Brown Trout and Coho Salmon) has been documented in tributaries upstream of the Berrien Springs Dam. These wild fish, which would not have been present without the fish ladders, also contribute to the fisheries in Lake Michigan.

Walleye is one of the most popular nonsalmonid game species in the St. Joseph River. As noted previously, the fish ladders have minimal effects on the Walleye population in this system. Thus, the only costs associated with maintenance of the Walleye fishery in the St. Joseph River are the annual fish stocking costs of $8,716. In the Michigan portion of the study area (which is where all Walleye stocking occurred), the mean annual benefit from the Walleye fishery was $199,776 (Table 12). Thus, the net economic benefit was $191,060.

Management Recommendations

Returns from MDNR stocking of Michigan-strain steelhead have been acceptable, and no changes to the current stocking protocol are recommended. In contrast, IDNR has had much lower return rates for Skamania-strain steelhead (Jonas et al. 2009). Given the poor overall return rates for Skamania and roughly equal catch rates for the two strains during June–August, IDNR should consider replacing their Skamania with Michigan-strain steelhead.

Any changes to the St. Joseph River stocking protocol must be considered in the larger context of the Lake Michigan fishery (Eshenroder et al. 1995). At the present time, the Chinook and Coho Salmon stocking programs appear to be producing a satisfactory fishery and should only be modified if necessary to restore a healthy predator : prey ratio in Lake Michigan. However, there may be an opportunity to improve the Brown Trout fishery in the St. Joseph River system by changing the strain used for stocking. MDNR recently developed a new Brown Trout strain from the Sturgeon River watershed in the northern Lower Peninsula. Some naturalized Brown Trout from this system have a potamodromous life history, spending part of their lives in large inland lakes. MDNR currently is evaluating survival and growth of Sturgeon River-strain and Wild Rose-strain Brown Trout at select Great Lakes ports, inland lakes, and large rivers. If the results of the evaluation indicate that Sturgeon River-strain fish have significantly better return rates than Wild Rose-strain fish, MDNR should begin stocking Sturgeon River-strain Brown Trout in the lower St. Joseph and Dowagiac rivers.

The lower St. Joseph River supports an acceptable Walleye fishery with harvest rates similar to those of other riverine Walleye fisheries in southwest Michigan. As noted previously, MDNR is in the process of assessing the relative contributions of stocked and wild fish to the Walleye population in the lower St. Joseph River. The Walleye stocking program will be reassessed once this study is completed. As noted above, these test fishways were ineffective at passing Walleye and other non-salmonids; new fishways should be installed by the private dam owners that allow full passage of all species except invasive species.

This project installed a series of fishways on the St. Joseph River at public expense to test fishway designs in the Midwest. The results of this study clearly indicate that additional fishways that pass a broad range of species are needed on this system to fully mitigate the effects of these privately-owned dams on fish passage. Such new fishways should be the financial obligation of the individual dam owners to ensure the full mitigation of fragmentation on this system. Fish ladders at large dams are expensive to construct and require frequent maintenance to remain operational. Even these few St. Joseph River

fish ladders have created additional fishing opportunities and yielded annual economic benefits to the local communities; however, as a result of a test system with insufficient fish passage, it will take many more years to recoup all of the initial investments in fish ladder and hatchery construction. Additional new fishways are needed and should be installed at dam owner expense. The expenses of long-term fishway maintenance and staff time commitments should be borne by the dam owners to fully mitigate the costs of fragmentation on this river system. If a dam is no longer meeting its original purpose (e.g., hydropower production), removal of the dam likely would be a less expensive option than ladder construction. Dam removal probably also would provide greater ecological benefits, as dams often cause direct mortality of fish (Cada 1990), interfere with the downstream movement of large woody structure, detritus, and sediment (Petts 1980; Shuman 1995), and alter stream water temperatures and flow regimes (Auer 1996; Paragamian et al. 2005; Friday 2006). These ecological effects are not alleviated by construction of fish ladders. However, managers also must consider the potential spread of aquatic invasive species, especially for dams that are the lowermost barriers on Great Lakes tributaries. For example, removal of the Berrien Springs Dam would allow sea lampreys to access many miles of spawning habitat upstream of the dam.

The lessons learned from the St. Joseph River fish ladders are applicable to the ongoing discussion regarding the future of the Pucker Street Dam on the Dowagiac River. This dam has not been used to generate electricity since 1996 and the impoundment has been drawn down since 1999 (Wesley 2008). The City of Niles currently is evaluating the potential costs and benefits of repairing and refurbishing the dam to generate electricity versus removal of the structure and elimination of the associated maintenance costs and liability. Removal of this structure would restore upstream fish passage to more than 100 miles of the main stem and tributaries and has been a priority management action for MDNR for more than a decade (Wesley and Duffy 1999; Wesley 2008). In addition to expanding fishing opportunities for steelhead and salmon, this option would reconnect fragmented populations of native fish species (e.g., Smallmouth Bass and White Sucker) and restore access to historic spawning and nursery habitat. As noted previously, fish ladder construction should not be considered as ecologically or economically equivalent to dam removal. If the City of Niles decides to remove the dam, MDNR will provide technical assistance and will work with other partners to acquire funding for the dam removal.

Acknowledgements

The author wishes to thank all the MDNR and IDNR creel clerks that collected the data summarized in this report. Tracy Kolb provided technical assistance and compiled data on angler residency and targeted effort. Donald Cole, Theresa Pohl, Neil Ledet, Dave Meuninck, and Ed Eisch assisted with calculation of fish stocking and ladder maintenance costs. Donna Wesander assisted with compilation of charter fishery data. Dave Caroffino, Jim Dexter, Neil Ledet, Jay Wesley, and Tracy Kolb provided thoughtful reviews on early drafts of this report. Dave Clapp was the lead editor, and Ellen Grove and Al Sutton assisted with formatting and publication of this report. This work was funded in part by the Federal Aid in Sport Fish Restoration Fund, Project F-81.

References

Anonymous. 1988. St. Joseph River fishery agreement between the State of Michigan and the State of Indiana. Michigan Department of Natural Resources, Lansing.

Auer, N. A. 1996. Response of spawning Lake Sturgeons to change in hydroelectric facility operation. Transactions of the American Fisheries Society 125:66-77.

Bell, M. C. 1986. Fisheries handbook of engineering requirements and biological criteria. United States Army Corps of Engineers, Fish Passage Development and Evaluation Program, Portland, Oregon.

Cada, G. F. 1990. A review of studies relating to the effects of propeller-type turbine passage on fish early life stages. North American Journal of Fisheries Management 10:418-426.

Clark, R. D., Jr., P. A. Hanchin, and R. N. Lockwood. 2004. The fish community and fishery of Houghton Lake, Roscommon County, Michigan, with emphasis on Walleyes and Northern Pike. Michigan Department of Natural Resources, Fisheries Special Report 30, Ann Arbor.

Dann, S. L., A. Alvarado, D. Palmer, B. Schroeder, and M. Stephens. 2008. Angler participation, recruitment, and retention in Michigan, 1995-2004: using data-mining techniques for customer relationship management. Michigan Department of Natural Resources, Fisheries Research Report 2088, Ann Arbor.

Dexter, J. L., Jr., and N. D. Ledet. 1994. Estimates of fish passage on the St. Joseph River in 1992 using time-lapse video recording. Michigan Department of Natural Resources, Technical Report 94-5, Ann Arbor.

Dexter, J. L., Jr., and N. D. Ledet. 1997. Estimates of fish passage on the St. Joseph River in 1993 using time-lapse video recording. Michigan Department of Natural Resources, Technical Report 95-4, Ann Arbor.

Dexter, J. L., Jr., and R. P. O'Neal. 2004. Michigan fish stocking guidelines II: with periodic updates. Michigan Department of Natural Resources, Fisheries Special Report 32, Ann Arbor.

Eshenroder, R. L., M. E. Holey, T. K. Gorenflo, and R. D. Clark, Jr. 1995. Fish community objectives for Lake Michigan. Great Lakes Fishery Commission, Special Publication 95-3, Ann Arbor, Michigan.

Friday, M. J. 2006. The migratory and reproductive response of spawning Lake Sturgeon to controlled flows over Kakabeka Falls on the Kaministiquia River, 2004. Ontario Ministry of Natural Resources, Upper Great Lakes Management Unit – Lake Superior, Technical Report 06.01, Thunder Bay.

Gunderman, B. 2010. Clear Lake. Michigan Department of Natural Resources, Status of the Fishery Resource Report 2010-104, Ann Arbor.

Hanchin, P. A., R. D. Clark, Jr., and R. N. Lockwood. 2005a. The fish community and fishery of Michigamme Reservoir, Iron County, Michigan with emphasis on Walleyes and Northern Pike. Michigan Department of Natural Resources, Fisheries Special Report 33, Ann Arbor.

Hanchin, P. A., R. D. Clark, Jr., R. N. Lockwood, and T. Cwalinski. 2005b. The fish community and fishery of Burt Lake, Cheboygan County, Michigan in 2001-02 with emphasis on Walleyes and Northern Pike. Michigan Department of Natural Resources, Fisheries Special Report 36, Ann Arbor.

Hanchin, P. A., B. J. Gunderman, and R. D. Clark, Jr. 2008. The fish community and fishery of the Cisco Lake Chain, Gogebic County, Michigan and Vilas County, Wisconsin with emphasis on Walleyes, Northern Pike, and Muskellunge. Michigan Department of Natural Resources, Fisheries Special Report 47, Ann Arbor.

Hanchin, P. A., and D. R. Kramer. 2008a. The fish community and fishery of North Manistique Lake, Luce County, Michigan in 2003-04 with emphasis on Walleyes. Michigan Department of Natural Resources, Fisheries Special Report 49, Ann Arbor.

Hanchin, P. A., and D. R. Kramer. 2008b. The fish community and fishery of South Manistique Lake, Mackinac County, Michigan in 2003-04 with emphasis on Walleyes, Northern Pike, and Smallmouth Bass. Michigan Department of Natural Resources, Fisheries Special Report 48, Ann Arbor.

Hotchkiss, R. H., and C. M. Frei. 2007. Design for fish passage at roadway-stream crossings: synthesis report. United States Department of Transportation, Federal Highway Administration, Publication #FHWA-HIF-07-033, McLean, Virginia.

James, W. D., D. E. Reynolds, and B. Fuchs. 1980. Environmental impact statement. A cooperative Indiana-Michigan anadromous fisheries program for the St. Joseph River, St. Joseph County, Indiana, and Berrien County, Michigan. Indiana Department of Natural Resources, Indianapolis.

Jonas, J. L., J. L. Dexter, Jr., N. Ledet, R. O'Neal, M. Wolgamood, and J. VanAmberg. 2009. Comparison of summer and winter run strains of steelhead returning to Lake Michigan fisheries. Michigan Department of Natural Resources, Final Research Report for Study 230487, Ann Arbor.

Lockwood, R. N., D. M. Benjamin, and J. R. Bence. 1999. Estimating angling effort and catch from Michigan roving and access site angler survey data. Michigan Department of Natural Resources, Fisheries Research Report 2044, Ann Arbor.

Paragamian, V. L., R. Hardy, and B. Gunderman. 2005. Effects of regulated discharge on Burbot migration. Journal of Fish Biology 66:1199-1213.

Petts, G. E. 1980. Long-term consequences of upstream impoundment. Environmental Conservation 7:325-332

Ryckman, J. R. 1981. Creel census methods in general. Appendix VI-A-9 in J. W. Merna, J. C. Schneider, G. R. Alexander, W. D. Alward, and R. L. Eshenroder, editors. Manual of fisheries survey methods. Michigan Department of Natural Resources, Fisheries Management Report 9, Lansing.

Seelbach, P. W., J. L. Dexter, Jr., and N. D. Ledet. 1994. Performance of steelhead smolts stocked in southern Michigan warmwater rivers. Michigan Department of Natural Resources, Fisheries Research Report 2003, Ann Arbor.

Shuman, J. R. 1995. Environmental considerations for assessing dam removal alternatives for river restoration. Regulated Rivers: Research & Management 11:249-261.

United States Department of the Interior, United States Fish and Wildlife Service, United States Department of Commerce, Economics and Statistics Administration, and United States Census Bureau. 1993a. 1991 national survey of fishing, hunting, and wildlife-associated recreation. United States Government Printing Office, Washington, D.C.

United States Department of the Interior, United States Fish and Wildlife Service, United States Department of Commerce, Economics and Statistics Administration, and United States Census Bureau. 1993b. 1991 national survey of fishing, hunting, and wildlife-associated recreation - Indiana. United States Government Printing Office, Washington, D.C.

United States Department of the Interior, United States Fish and Wildlife Service, United States Department of Commerce, Economics and Statistics Administration, and United States Census Bureau. 2007. 2006 national survey of fishing, hunting, and wildlife-associated recreation. United States Government Printing Office, Washington, D.C.

United States Department of the Interior, United States Fish and Wildlife Service, United States Department of Commerce, Economics and Statistics Administration, and United States Census Bureau. 2008a. 2006 national survey of fishing, hunting, and wildlife-associated recreation - Indiana. United States Government Printing Office, Washington, D.C.

United States Department of the Interior, United States Fish and Wildlife Service, United States Department of Commerce, Economics and Statistics Administration, and United States Census Bureau. 2008b. 2006 national survey of fishing, hunting, and wildlife-associated recreation - Michigan. United States Government Printing Office, Washington, D.C.

Wesley, J. K. 2008. Dowagiac River – Pucker Street Dam draw down experience. Michigan Department of Natural Resources, Status of the Fishery Resource Report 2008-58, Ann Arbor.

Wesley, J. K., and J. E. Duffy. 1999. St. Joseph River assessment. Michigan Department of Natural Resources, Fisheries Special Report 24, Ann Arbor.

Wills, T. C. 2006. Comparative abundance, survival, and growth of one wild and two domestic Brown Trout strains stocked in Michigan rivers. North American Journal of Fisheries Management 26:535-544.

David C. Caroffino, Reviewer
David F. Clapp, Editor
Alan D. Sutton, Graphics Production and Desktop Publisher
Ellen S. Grove, Desktop Publisher Approved by Gary E. Whelan