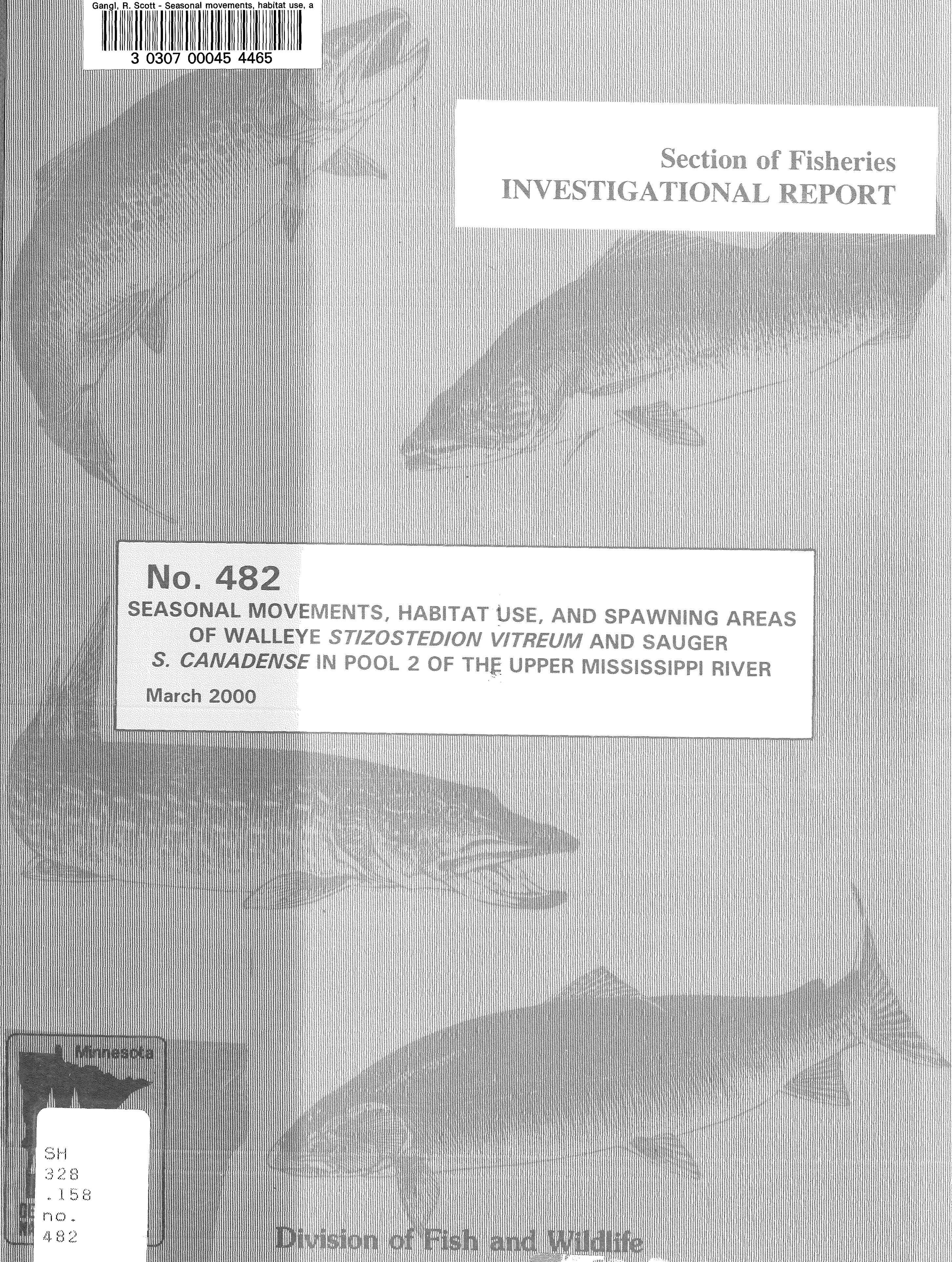

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No. 482

SEASONAL MOVEMENTS, HABITAT USE, AND SPAWNING AREAS OF WALLEYE *STIZOSTEDION VITREUM* AND SAUGER *S. CANADENSE* IN POOL 2 OF THE UPPER MISSISSIPPI RIVER

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SEASONAL MOVEMENTS, HABITAT USE, AND SPAWNING AREAS OF WALLEYE *STIZOSTEDION VITREUM* AND SAUGER *S. CANADENSE* IN POOL 2 OF THE UPPER MISSISSIPPI RIVER

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Abstract.--We used radio telemetry to determine seasonal movements, habitat use, and spawning areas of walleye *Stizostedion vitreum* and sauger *S. canadense* in navigational Pool 2 of the Mississippi River. Pool 2 is the area between Lock and Dam 1 and Lock and Dam 2. Twenty-seven walleye and 25 sauger were implanted with radio transmitters, and tracked by boat and airplane between 1 February 1998 and 26 May 1999. The most significant movements by both species occurred during spring, when several fish traveled up the Minnesota River. Mean range did not differ significantly between walleye (27.5 km) and sauger (41.2 km). Mean daily movement differed significantly between walleye (34.7 m/day) and sauger (51.0 m/day). Individual ranges for both species varied substantially. We documented walleye spawning in the area downstream of Lock and Dam 1. Walleye eggs were collected sporadically at other locations throughout Pool 2, but the sources could not be pinpointed. No sauger eggs were collected. Mean depth was lowest for sauger during summer, and did not differ by season for walleye. Mean depth differed significantly between walleye and sauger during spring and summer. Both species were most frequently located over sand and silt substrate, but walleye showed more use of gravel and cobble than sauger. Macrohabitat use was similar for both species overall, but seasonal uses varied. Only walleye were located near the main channel and wing dams during summer and winter, respectively. Walleye were located in tailwaters much more frequently than sauger. We located sauger in backwaters and side channels more frequently during summer and fall, respectively, than walleye. Electrofishing during fall produced high walleye catch rates in the tailwaters of Lock and Dam 1 (61 fish/hour) and on wing dams in middle Pool 2 (51.3 fish/hour). Spring electrofishing in tailwaters also produced high walleye catch rates (74.5 fish/hour), but catch rates in lower Pool 2 were much lower (5.5 fish/hour).

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Introduction

In 1993, the Minnesota Department of Natural Resources (DNR) imposed a catch and release only fishing regulation on walleye *Stizostedion vitreum*, sauger *S. canadense*, largemouth bass *Micropterus salmoides*, and smallmouth bass *M. dolomieu* for navigational Pool 2 of the Upper Mississippi River. The goal of this regulation was to maintain or improve the quality of angling for these species. Pool 2 has a reputation for excellent angling success for walleye and sauger during the winter months, generally from December-February, and catch rates are highest at this time (Gorton 1993, 1998). However, fishing pressure is much greater during the summer than winter, while catch rates of walleye and sauger during summer are much lower than winter. This leads local fishery managers to question why most fish are caught when fishing pressure is the lowest. One hypothesis is that during the winter walleye and sauger stage in Pool 2 prior to spawning movements in the spring, making them more vulnerable to anglers. Once spawning has occurred, these fish may disperse to summer areas, which may include areas outside of the pool. It is unknown whether walleye and sauger caught during winter are permanent residents of the pool, or whether they navigate through the locks and dams or migrate into the Minnesota River at various times of the year. Sampling efforts by the DNR, as needed for population assessment, have been largely unsuccessful for walleye and sauger in Pool 2 during summer. It is important to determine whether walleye and sauger remain in Pool 2 throughout the year (and thus, are protected by the catch and release regulation), or whether they leave the pool at certain times of the year, becoming vulnerable to harvest. If these fish are remaining in the pool throughout the year, information on their movements and habitat use would be beneficial to improve population assessment.

Natural reproduction is very important to walleye and sauger populations in Minnesota waters of the Upper Mississippi River, since these species are not stocked. Spawning movements and critical spawning habitat in Pool 2 may be subject to disturbances due to urban development and other human activities (e.g., channel dredging). Previous studies have shown that the specific spawning habitat requirements for walleye and sauger can differ substantially among individual pools of the river. Holzer and Von Ruden (1984) found that walleye used submerged reed canary grass *Phalaris arundinacea* for spawning in Pool 8, while Pitlo (1983) found that walleye spawned on sand, gravel, cobble, and a freshwater mussel bed adjacent to the main river channel in Pool 13. Siegwarth (1993) reported the use of a tributary for spawning by both walleye and sauger. Gebken and Wright (1972) reported collecting ripe walleye and walleye eggs in the tailwaters of Lock and Dam 6, in Pool 7. Brooks (1993) reported sauger spawning in tailwaters in the Peoria Pool of the Illinois River, while Freiermuth (1987) documented sauger spawning on wing dams just downstream of Lock and Dam 3, in Pool 4. Identification of critical spawning areas in Pool 2 is important for protecting these areas from disturbances and habitat loss that may affect walleye and sauger reproduction.

The objectives of this project are 1) to identify seasonal movements of walleye and sauger in Pool 2, particularly inter-pool movement, 2) to locate walleye and sauger spawning areas in Pool 2, and 3) to increase population assessment sampling efficiency through analysis of movements and habitat use.

Study Site

The Mississippi River is the largest river in North America. In the 1930s, the United States Army Corps of Engineers began installation of a system of locks and dams on the Upper Mississippi River. The purpose of these dams is to maintain a 2.7 m channel depth, which is necessary for commercial navigation. Navigational Pool 2 is the area between Lock and Dam 1 in St. Paul, MN, and Lock and Dam 2, near Hastings, MN (Figure 1). The pool is approximately 52 km in length (channel length), and has an area of 4,274 ha. There are eight public boat access sites throughout Pool 2, plus several private accesses and marinas.

Due to distinctly different characteristics, Pool 2 can be described as three portions for

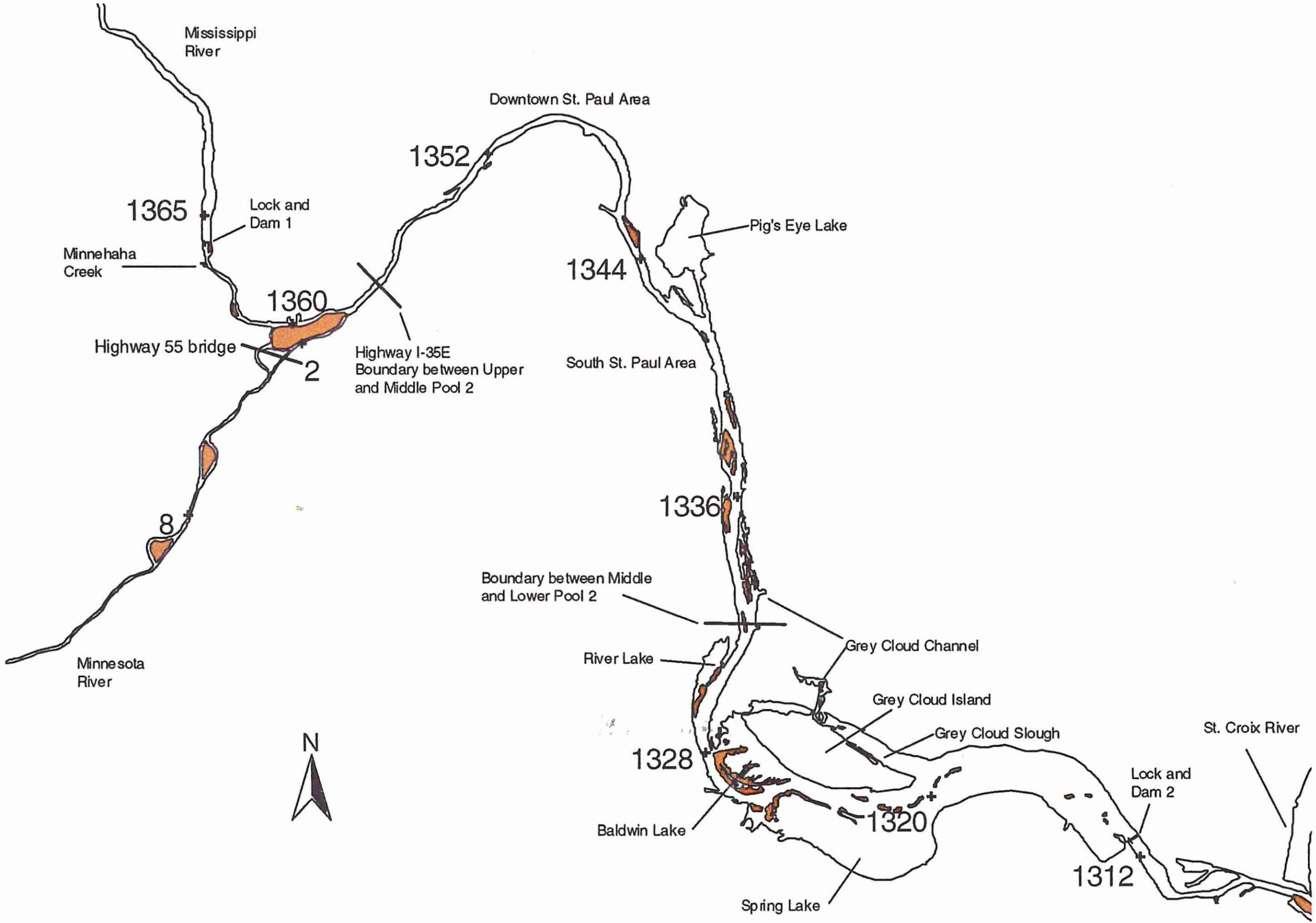

Figure 1. Study area, illustrating major features of Pool 2 of the Upper Mississippi River. Numbers associated with the cross (✚) symbol indicate the distance, in kilometers, upstream from the confluence with the Ohio River.

this study (Figure 1). Upper Pool 2 runs from Lock and Dam 1 downstream approximately 7 km to the I-35E bridge. Contained within this section are the confluences with the only two major tributaries to Pool 2, Minnehaha Creek and the Minnesota River. Minnehaha Creek enters Pool 2 approximately 0.4 km downstream from Lock and Dam 1, and is considered part of Pool 2 from its mouth upstream to a waterfall that blocks fish movement. The Minnesota River enters Pool 2 approximately 5.6 km downstream from Lock and Dam 1, essentially doubling the size of the Mississippi River from the point of their confluence downstream. It is considered part of Pool 2 upstream to the highway 55 bridge. Upper Pool 2 is the most riverine section of the pool, with few structures to direct water flow. Most of the shoreline of Upper Pool 2 is composed of regional or state park land, with mostly deciduous forests and little urban development. Middle Pool 2 runs from the I-35E bridge downstream approximately 24 km to the upper channel of Grey Cloud Slough. This portion of Pool 2 is mostly riverine, but it has been altered to facilitate commercial navigation. Numerous wing dams have been installed to direct water flow into the main navigation channel. Middle Pool 2 flows through downtown St. Paul, and is highly developed for commercial shipping purposes. One water source to this section consists of the treated water effluent from the Pig's Eye Waste Water Treatment Plant. One major backwater, Pig's Eye Lake, is located in this section. Channel braiding occurs at the lower portion of this section. Most of the successful winter walleye and sauger fishing occurs in Middle Pool 2. Lower Pool 2 encompasses the area from the upper channel of Grey Cloud Slough downstream approximately 21 km to Lock and Dam 2. Lower Pool 2 has more lacustrine characteristics than the upper portions. Much of the surface area in Lower Pool 2 is composed of backwater areas such as River Lake, Spring Lake, Baldwin Lake, and Grey Cloud Slough. Shorelines are primarily high bluffs, with a mixture of commercial and private development.

Methods

Radio Telemetry

We collected walleye and sauger using electrofishing and angling. Angling was used to collect fish targeted by anglers during winter by focusing sampling to locations where angling success has historically been high, typically in Middle Pool 2. We implanted 40 fish (20 walleye and 20 sauger) during the fall and winter of 1997-98, and another 12 fish (7 walleye and 5 sauger) during the winter of 1998-99, with radio transmitters. During the first tagging event, we attempted to distribute 20 of the transmitters equally by species and sex throughout the pool. The remaining 20 transmitters were implanted in fish targeted by anglers during winter. We targeted only male walleye and sauger during the second tagging event. On-site surgeries were performed to implant radio transmitters using a V-shaped surgery trough (described by Brian Blackwell, SD Dept. of Game, Fish, and Parks, personal communication), placed at an angle in a water-filled plastic tub. We used procedures similar to those described by Hart and Summerfelt (1975) and Pitlo (1978, personal communication) to implant radio transmitters into the abdominal cavity of each fish. Upon completion of surgery, fish were placed in a tank of water to assess post-surgery condition, and subsequently released near the site of collection. A numbered, yellow dart tag was attached near the dorsal fin of each fish for individual identification. Assuming that implantation would affect behavior, fish were monitored, but data collection was delayed for at least one week following tagging.

Three sizes of radio transmitters were used for this study. Ten transmitters were 66 mm long and weighed 30 g, with a life expectancy of approximately 1,500 days. Thirty transmitters were 46 mm long and weighed 20 g, with a life expectancy of 1,040 days. Twelve transmitters were 56 mm long, weighed 11 g, and had a life expectancy of approximately 180 days. The weight of the transmitter in air should not exceed 2% of the fish's weight out of water (Winter 1996). Therefore, we attempted to implant the three types of transmitters in fish weighing 1,500 g, 1,000 g, and 550 g, respectively. All transmitters operated on the 48-MHZ band, and each transmitter had a unique frequency, that allowed identification of individual fish. In this report, individual fish are referred to by their unique kHz designation (e.g., sauger frequency 48.680 is referred to as sauger 680). During tracking, each fish was initially located with a four-element Yagi boom antenna, tuned to the 48-MHZ range. A small wire loop antenna was used to more precisely locate each fish. An exposed end of coaxial cable was used to determine fish locations to within 5 m (Niemala et al. 1993).

For each fish located, we recorded date, location, water depth (m), and substrate type. Substrate type was determined either visually using a ponar dredge or by contact using an oar or similar device. Substrate types were categorized as clay, muck, silt, sand, gravel, cobble, boulder, bedrock, and detritus (Sternberg 1978). The location coordinates for each fish were recorded from a hand-held global positioning system. Differentially corrected UTM coordinates were recorded to ensure the accuracy of coordinates. To cover a larger search area and to locate "lost" fish (i.e., fish that hadn't been located in recent tracking events), we used an airplane with antennas mounted to the wing struts (Gilmer et al. 1981). Fish locations determined via airplane were either plotted on a map, without further collection of data, or were subsequently pinpointed using the boat and data collection methods outlined above. Boat tracking events were conducted by attempting to search the entire portion of Pool 2 every two weeks for most of the study, with more intense tracking done during periods of high movements (e.g., pre- and post-spawn). Attempts were made to locate all fish during each tracking event.

Location data for all fish were analyzed using a Geographic Information System (GIS) utilizing ArcView software. Ranges were calculated as the total linear distance (km) between the extreme upstream and downstream locations for each fish. Mean daily movements (km/day) were used to quantify activity for each fish. Mean daily movement was calculated as the total distance traveled by an individual fish divided by the number of days that fish was at large. Wilcoxin Rank Sums tests (Sall and Lehman 1996) were used to determine whether ranges and mean daily movements differed between species. JMP IN statistical software (SAS Institute Inc. 1996) was used to perform statistical analyses on movement and microhabitat data. An alpha level of 0.05 was used to detect statistical significance.

Spawning Site Location

We combined locations of mature fish, angler reports of ripe fish, and presence of suitable habitat to determine suspected spawning areas. Once suspected spawning areas were identified, three methods were employed to collect eggs or larvae for verification. An epibenthic egg sampling sled (Medlin 1990) was used to attempt collection of eggs during the spring of 1998. We used fine-mesh dip nets to attempt egg collection in shallow water (<1.2 m), with little or no flow. The lip of the net was used to agitate substrate and suspend material from the bottom. The resulting suspended material was then strained through the mesh of the net. In 1999, we used drift nets and methods similar to those described by Pitlo (1989) and Siegwarth (1993) to collect drifting eggs. Drift nets were set downstream of suspected spawning areas as stationary sets. The initiation of net-setting corresponded to sudden, usually long-distance movements of both species that were assumed to be spawning-related. Nets were checked and emptied every Monday, Wednesday, and Friday, 5-30 April. Fish eggs were transported to the DNR Metro Hatchery for incubation. Larval fish were preserved in alcohol, and identified according to the key by Auer (1982) and descriptions by Holland-Bartels et al. (1990). Egg sampling ended when no more eggs were collected in drift nets for at least one week.

Population Assessment Sampling Efficiency

Mean water depth data was analyzed by season to determine what areas and microhabitat combinations are utilized by each species. Seasons were defined as: Winter (December-February), Spring (March-May), Summer (June-August), and Fall (September-November).

Tukey-Kramer Honest Significant Difference (HSD) tests and Wilcoxin Rank Sum tests (Sall and Lehman 1996) were performed to determine whether mean water depth differed significantly by species and season. An alpha level of 0.05 was used to detect statistical significance for Wilcoxin Rank Sum tests.

Because macrohabitat use was not measured in the field, we used GIS to determine what macrohabitat each fish location was associated with. Macrohabitat categories were defined as backwater (large areas of standing water), main channel (relating to the main navigational channel), channel border (area of reduced current adjacent to the main channel), side channel (channel other than main channel with substantial flow), wing dam (man-made flow control structure), and tailwater (the area directly below a dam).

We used night electrofishing to determine when optimal sampling might occur. Foursampling events occurred during the fall period between 3 November 1998 and 16 December 1998. The fall sampling period was initially intended to collect walleye maturity data for a separate study, and did not require effort documentation. Thus, only walleye were targeted and catch-per-unit-effort (CPUE) was calculated using estimated sampling times. Three sampling events occurred during the spring period between 1 June 1999 and 17 June 1999. Only walleye were targeted during spring sampling, and sampling time was recorded to calculate CPUE. Water temperatures during both sampling periods were obtained from U. S. Army Corps of Engineers data (www.mvp-wc.usace.army.mil/projects/Lock1.html).

Results

Radio Telemetry

Twenty-five sauger (Table 1; Figure 2) and 27 walleye (Table 2; Figure 2) were captured and implanted with radio transmitters. Implanted sauger ranged from 375-555 mm in total length (TL) and ages 2-8. Due to minimum body-size requirements to accommodate radio transmitters, most sauger implanted during the first tagging event were larger females. Implanted walleye ranged from 364-705 mm TL and ages 3-10+. Male walleye have been reported to stay near spawning areas longer than females (Priegel 1970; Colby et al. 1979). Therefore, the second tagging event was directed at males of both species to improve the ability to identify spawning areas. Several fish were considered to have died during the study (Tables 1 and 2), and the date of last location for these fish corresponds to the date that the fish was first located at the site of mortality.

Data was collected from 01 February 1998 through 26 May 1999. Several fish died or were not located frequently enough to provide useful data, and were omitted from movement or microhabitat use analyses (Tables 1 and 2). Ninety-four locations were made for 17 sauger, with an average of 5.6 locations per fish (Table 3). Two-hundred twenty-two locations were made for 24 walleye, with an average of 9.3 locations per fish (Table 4). The mean number of locations per fish differed significantly between walleye (9.3) and sauger (5.6) (p-value = 0.0398).

Several study fish were caught and released by anglers during the study. Sauger 881 was caught and released by an angler near river kilometer 1345 on 18 December 1997. Walleye 790 was caught and released by an angler near its tagging site on 01 January 1998. Walleye 410 was caught and released by an angler during May 1998 near river kilometer 1358. Walleye 811 was caught and released by an angler during August 1998, near river kilometer 1335. There were several other reports of fish caught by anglers. However, the tag numbers were not recorded and the reports weren't confirmed. One angler reported catching and releasing several radio-tagged fish near the mouth of Minnehaha Creek during the spring of 1998.

Sauger range varied from 2.3 km to 120.5 km, with a mean of 41.2 km (Table 3). Mean daily movement of sauger was also variable, ranging from 0.04 km/day to 1.67 km/day, with an average of 0.42 km/day. A substantial number of sauger (numbers 580, 630, 660, 700, 710, 781, and 831) showed movements to the Minnesota River during Spring 1998 (Figure 3). The maximum distance of any sauger location upstream of the confluence of the Minnesota and

Table 1. Data collected from sauger implanted with radio transmitters between 02 October 1997 and 23 February 1999 in Pool 2 of the Upper Mississippi River.

Date implanted	Weight (g) of transmitter	Frequency	Total length (mm)	Weight (g)	Age	Sex	Date last located	Days at large
02 Oct 97	20	48.821[c]	477	925	5	F	23 Dec 97[a]	82
16 Oct 97	30	48.331[c]	555	1400	8	?	16 Oct 97[b]	0
16 Oct 97	20	48.881[c]	477	1025	5	F	20 Dec 97	65
16 Oct 97	20	48.941[c]	484	1250	6	?	25 Mar 98[a]	160
29 Oct 97	20	48.781	519	1275	7	?	12 Jun 98[a]	226
02 Jan 98	20	48.651[c]	494	1200	6	F	09 Mar 98	66
02 Jan 98	20	48.710	496	1150	5	F	17 Mar 98	74
06 Jan 98	20	48.660	437	900	5	F	10 Jun 98[a]	155
07 Jan 98	20	48.630	458	800	6	M	04 Mar 98	56
07 Jan 98	20	48.700	462	1400	6	F	22 Nov 98[a]	319
07 Jan 98	20	48.670	451	1025	5	F	06 Aug 98[a]	211
30 Jan 98	20	48.931[c]	505	1480	6	M	08 Apr 99	433
30 Jan 98	20	48.831	544	1670	8	F	06 Aug 98	188
30 Jan 98	20	48.961	536	1540	7	M	26 May 99	481
30 Jan 98	20	48.640	473	1160	6	F	26 Jan 99	361
30 Jan 98	20	48.610	459	990	5	F	26 May 99	481
30 Jan 98	20	48.741	536	1660	8	F	21 Jan 99[a]	356
30 Jan 98	20	48.892[c]	487	1250	7	F	24 Apr 98[a]	84
30 Jan 98	20	48.580	485	1170	6	F	12 Jun 98[a]	133
03 Feb 98	20	48.680[c]	468	1025	5	F	27 May 98[a]	113
02 Feb 99	11	48.111	439	741	2	M	24 Mar 99	50
09 Feb 99	11	48.081	393	636	3	M	26 May 99	106
09 Feb 99	11	48.042	383	510	5	M	23 Apr 99	73
09 Feb 99	11	48.061[c]	394	612	5	M	09 Feb 99[b]	0
23 Feb 99	11	48.091	375	520	3	M	20 Apr 99	56

[a]Fish presumed dead at last location
[b]Fish never located after tagging
[c]Fish omitted from further analyses due to lack of consistent locations

Mississippi Rivers in 1998 was 92 km (sauger 660; 10 June 1998). These seven sauger represented 35% of the sauger tagged in 1998. After adjusting the total number of fish to include only those fish regularly located during this time period (i.e., deceased or lost fish were removed from the calculation), the number of sauger located in the Minnesota River in 1998 was 50% of the total. Two sauger (042, 111) were located in the Minnesota River in 1999 (Figure 3). The maximum distance of any sauger location upstream of the confluence of the Minnesota and Mississippi Rivers in 1999 was 33 km (sauger 111; 24 March 1999). These two sauger represented 8% of the total number of sauger tagged during this study, and 29% of the sauger regularly located during this time period. Locations of sauger in the Minnesota River occurred exclusively during spring periods, with most fish returning to Pool 2 by early May. The remaining sauger (those that didn't travel up the Minnesota River) remained in Pool 2 at or near tagging areas (Figure 4).

The majority of Summer 1998 sauger locations were made in Lower Pool 2 (Figure 5). Four sauger (670, 700, 831, and 961) were located regularly in or near backwater lakes and other backwater areas, including Spring Lake, Baldwin Lake, and the area directly above Lock and Dam 2. These fish utilized water depths ranging from 0.3 m to 2.7 m. Two additional sauger were located in Lower Pool 2 during Summer 1998. Sauger 580 and 781 were located 5.6 km to 6.5 km upstream of Lock and Dam 2. Subsequent locations of these fish led to the presumption that they were dead.

Difficulties locating fish and a series of equipment problems led to an extremely low number of sauger locations during Fall 1998. Only three sauger (610, 700, and 961) were

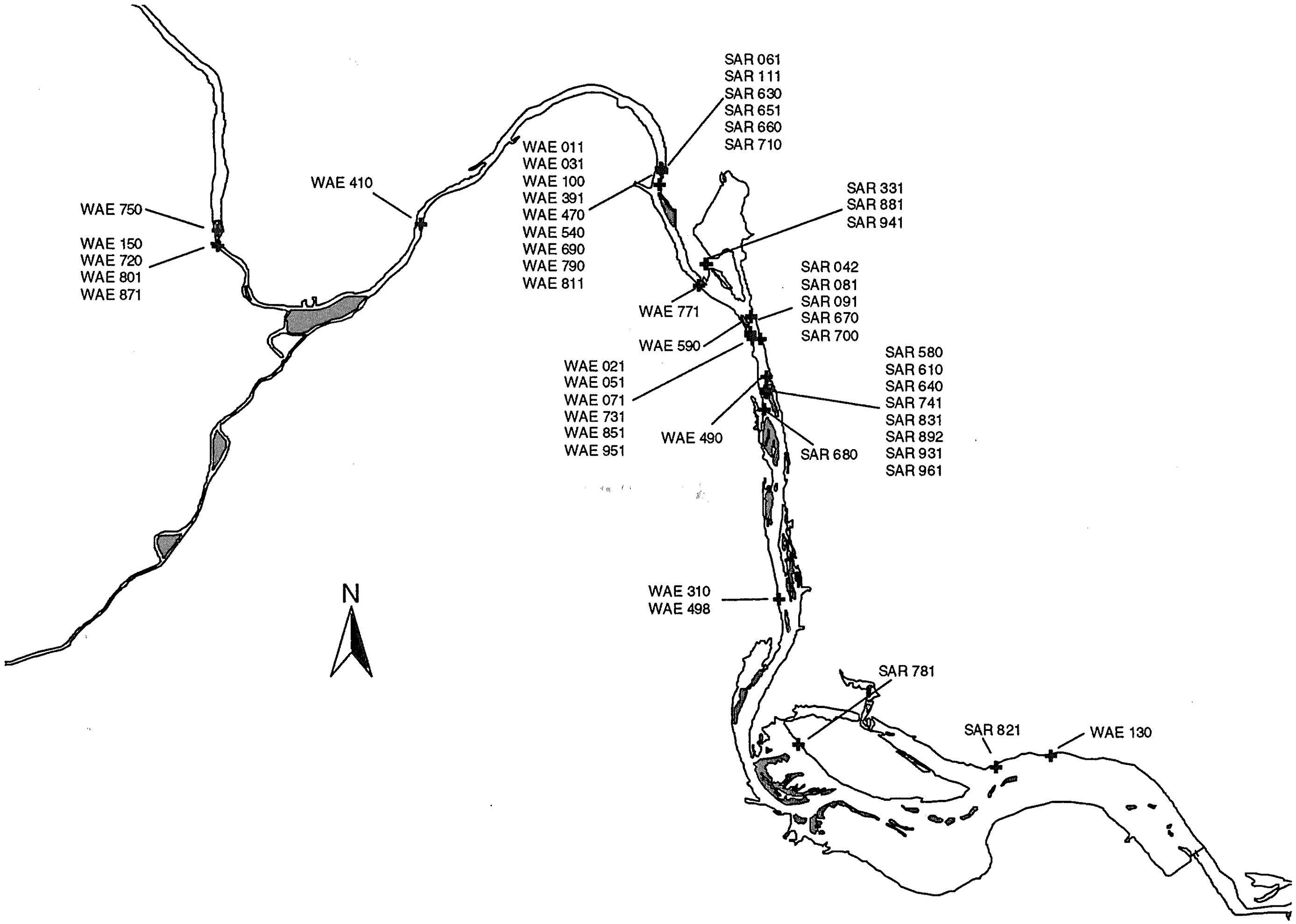

Figure 2. Release sites of sauger and walleye implanted with radio transmitters, 1997-99, in Pool 2 of the Upper Mississippi River. Labels correspond to transmitter frequencies for individual fish. See Tables 1 and 2 for individual fish information.

Table 2. Data collected from walleye implanted with radio transmitters between 09 October 1997 and 27 February 1999 in Pool 2 of the Upper Mississippi River.

Date implanted	Weight (g) of transmitter	Frequency	Total length (mm)	Weight (g)	Age	Sex	Date last located	Days at large
09 Oct 97	30	48.410	544	1500	6	M	21 May 99	589
09 Oct 97	30	48.750[c]	521	1350	5	?	05 Apr 98[a]	178
15 Oct 97	30	48.150	580	1950	4	?	17 Jun 98	245
15 Oct 97	20	48.720	498	1150	5	M	16 Jul 98	274
15 Oct 97	20	48.801	507	1350	5	?	16 Jul 98[a]	274
15 Oct 97	20	48.871	484	1000	4	F	25 May 99	587
16 Oct 97	20	48.771	543	1700	5	F	04 May 98	200
16 Oct 97	20	48.790	515	1125	5	M	17 Dec 98	427
22 Oct 97	30	48.130	601	2400	6	F	11 Jun 98[a]	232
05 Nov 97	30	48.310	705	4300	10+	F	25 Mar 99	505
05 Nov 97	30	48.498	629	3875	10	F	14 Dec 98[a]	404
15 Dec 97	30	48.490	675	3810	9	F	15 Sep 98	274
02 Jan 98	30	48.391[c]	617	2500	6	F	27 Mar 98	84
02 Jan 98	30	48.470	625	2300	7	F	06 May 99[a]	124
02 Jan 98	20	48.690	490	1125	4	M	17 Jul 98	166
07 Jan 98	20	48.811	493	1025	5	M	26 May 99	504
07 Jan 98	20	48.590	465	1000	4	M	13 May 99	491
03 Feb 98	20	48.851	461	1010	4	M	28 Sep 98[a]	237
03 Feb 98	20	48.731	615	2500	7	F	26 May 99	477
03 Feb 98	20	48.951	471	990	4	M	21 May 99	472
02 Feb 99	11	48.031	410	595	3	M	21 Apr 99[a]	81
02 Feb 99	11	48.011	440	665	4	M	25 May 99	112
08 Feb 99	11	48.100	460	948	3	M	25 May 99	106
09 Feb 99	11	48.540	436	764	3	M	08 Apr 99[a]	58
23 Feb 99	11	48.071	375	480	3	M	28 Apr 99	64
23 Feb 99	11	48.021[c]	400	670	3	M	23 Feb 99[b]	0
27 Feb 99	11	48.051	364	435	3	M	25 May 99	88

[a]Fish presumed dead at last location
[b]Fish never located after tagging
[c]Fish omitted from further analyses due to lack of consistent locations

Table 3. Linear range and mean daily movements (total distance traveled/days at large) for sauger implanted with radio transmitters in Pool 2 of the Upper Mississippi River, 1997-99.

Frequency	Number of locations	Range (km)	Mean daily movement (km/day)
781	5	59.9	0.56
710	2	47.3	0.64
660	2	108.1	0.68
630	1	30.5	0.54
700	13	44.7	0.24
670	10	20.6	0.13
831	6	45.8	0.42
640	4	2.3	0.12
961	17	35.5	0.14
610	7	19.1	0.05
741	5	31.0	0.14
580	3	120.5	1.67
111	3	43.7	0.87
81	3	21.3	0.21
42	3	22.1	0.30
91	6	6.2	0.15
Mean (SD)	5.6 (4.3)	41.2 (32.5)	0.42 (0.42)

Table 4. Linear range and mean daily movements (total distance traveled/days at large) for walleye implanted with radio transmitters in Pool 2 of the Upper Mississippi River, 1997-99.

Frequency	Number of locations	Range (km)	Mean daily movement (km/day)
498	3	55.4	0.26
951	19	51.7	0.22
851	7	8.3	0.08
811	25	28.9	0.18
690	5	32.8	0.20
51	5	6.0	0.14
71	7	1.1	0.03
100	7	8.1	0.10
540	4	18.1	0.34
771	3	33.0	0.17
871	8	23.1	0.04
801	12	12.2	0.06
720	10	11.0	0.14
150	12	4.5	0.03
410	22	36.0	0.15
130	3	24.7	0.22
310	17	33.1	0.17
590	4	17.6	0.04
790	17	0.6	0.01
731	13	114.6	0.66
490	4	74.8	0.57
470	3	55.1	0.82
11	8	9.2	0.10
31	4	6.5	0.09
Mean (SD)	9.25 (6.5)	27.8 (27.0)	0.20 (0.21)

located during this period, all of which occurred on 22 November 1998 (Figure 6) in Lower Pool 2. Sauger 700 was subsequently presumed dead at this location. Sauger 961 was located in a main-channel border area near the upper portion of Grey Cloud Island.

Winter tracking results includes both the winters of 1997-98 and 1998-99. During both winter periods, sauger locations were predominantly made in Middle Pool 2 (Figure 7). This likely corresponded to nearby tagging areas, since most sauger tagging was performed during winter periods. All sauger included in the analysis, except number 781, were tagged in Middle Pool 2. Sauger 781 was tagged in Lower Pool 2 on 29 October 1997, but was located in Middle Pool 2 during winter 1997-98.

Walleye range varied from 0.6 km to 114.6 km, with a mean of 27.8 km (Table 4). Mean range did not differ significantly between walleye and sauger (p-value = 0.1324). Mean daily movement of walleye ranged from 0.01 km/day to 0.82 km/day, with an average of 0.20 km/day. Walleye average mean daily movement was significantly less than sauger mean daily movement (p-value = 0.0484). A substantial number of walleye (numbers 470, 490, 498, 731, and 771) were located in the Minnesota River during spring 1998 (Figure 3). This represented 25% of the total number of walleye tagged and 26% of the walleye that were being located regularly at this time. The maximum distance of any walleye locations upstream of the confluence of the Minnesota and Mississippi Rivers in 1998 was 37 km (walleye 490; 17 March 1998). Three walleye (410, 731, 951) were located in the Minnesota River during Spring 1999 (Figure 3). These three fish represented 11% of the total number of walleye tagged for the study, and 23% of the tagged fish that were being regularly located during this period. The maximum distance of any walleye locations upstream of the

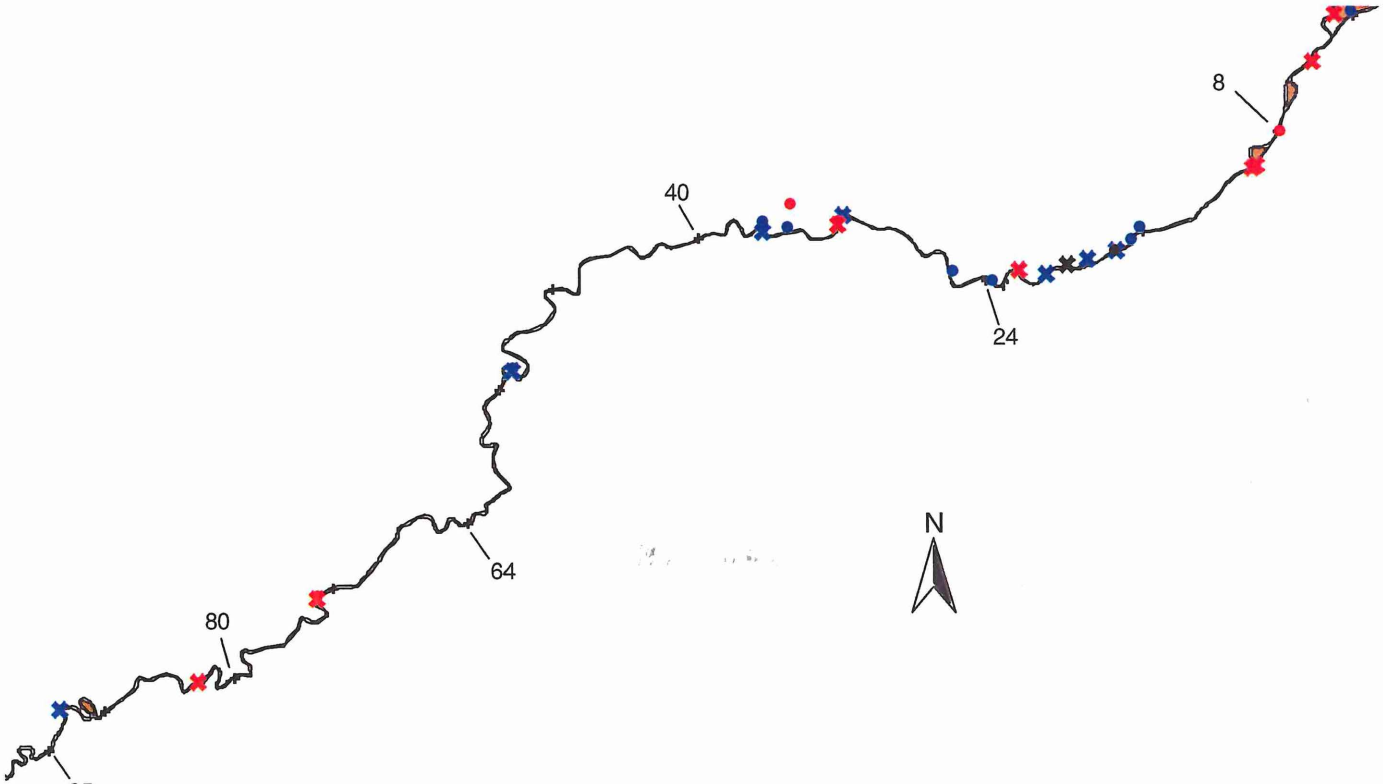

Figure 3. Locations during spring of radio-tagged sauger (✖= March, ✖ = April, and ✖ = May) and walleye (• = April, • = April, and • = May) in the Minnesota River. Numbers associated with the cross (✚) symbol indicate the distance, in kilometers, upstream from the confluence with the Mississippi River. Note that some points may reflect multiple locations of individual fish. One walleye was located in a flooded backwater during April 1998, and appears in the figure as a point outside of the river boundaries.

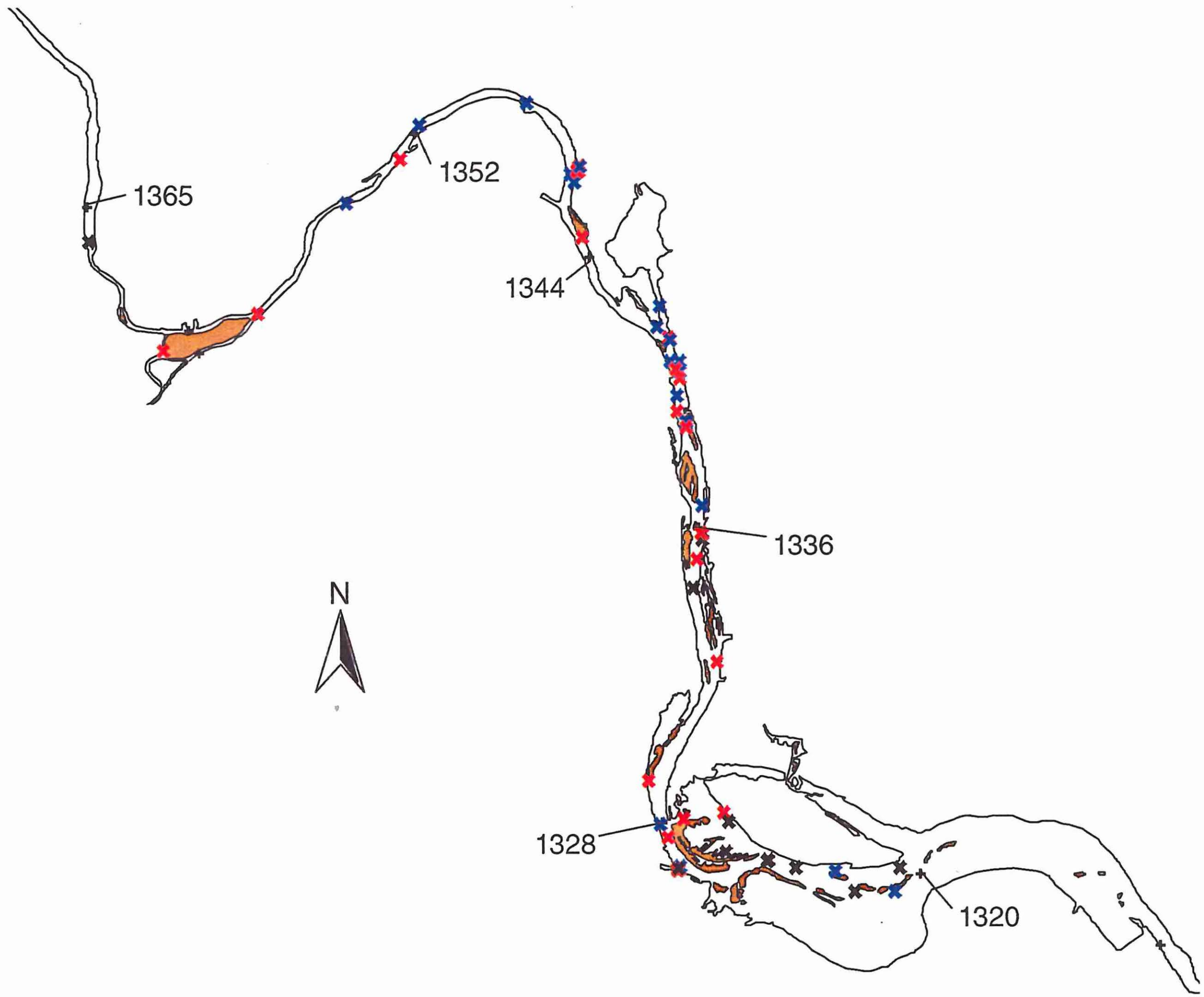

Figure 4. Locations during spring of radio-tagged sauger (✖ = March, ✖ = April, and ✖ = May) in Pool 2. Numbers associated with the cross (✚) symbol indicate the distance, in kilometers, upstream from the confluence with the Ohio River. Note that some points may reflect multiple locations of individual fish.

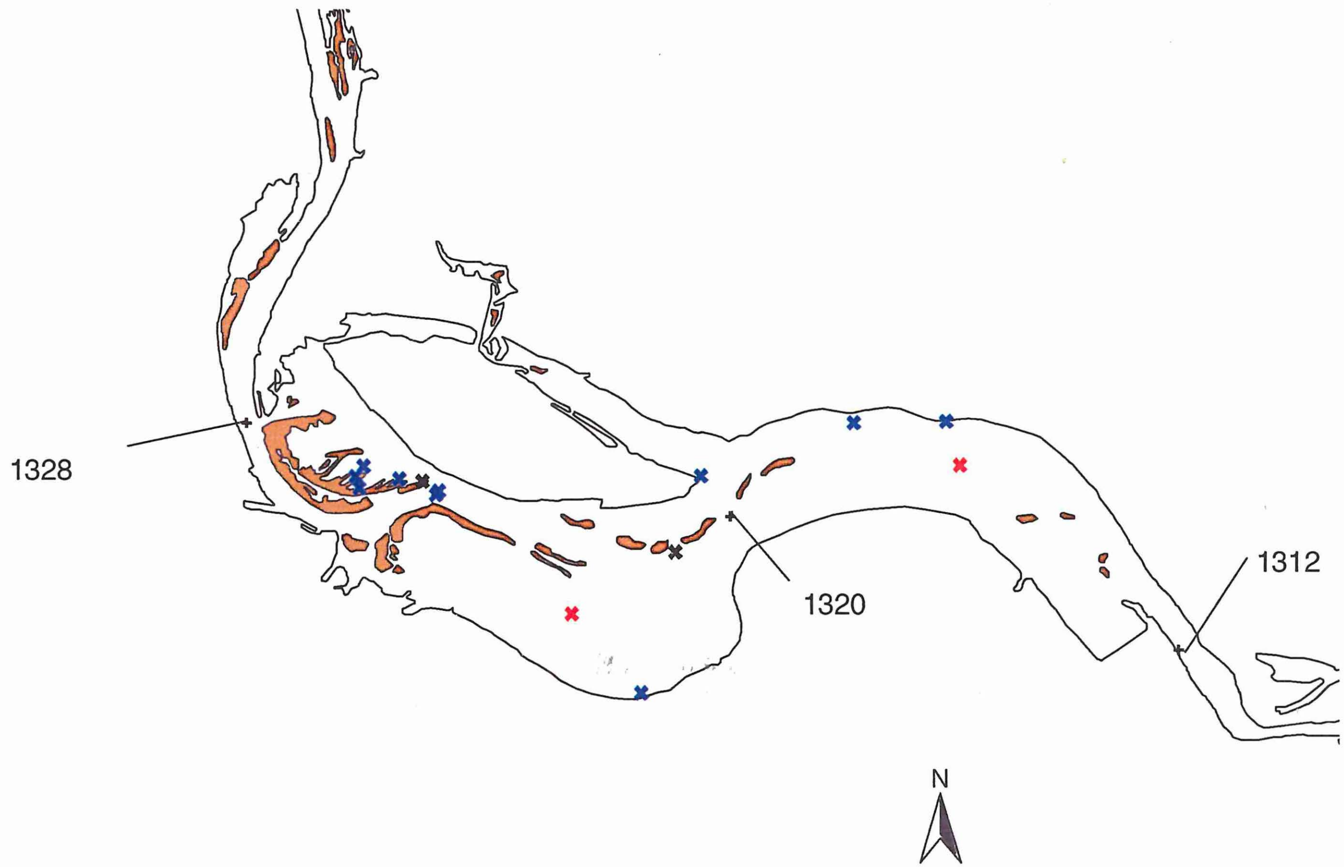

Figure 5. Locations during summer of radio-tagged sauger (✖ = June, ✖ = July, and ✖ = August). Numbers associated with the cross (✚) symbol in Pool 2 indicate the distance, in kilometers, upstream from the confluence with the Ohio River, and in the Minnesota River indicate the distance upstream from the confluence with the Mississippi River. Note that some points may reflect multiple locations of individual fish.

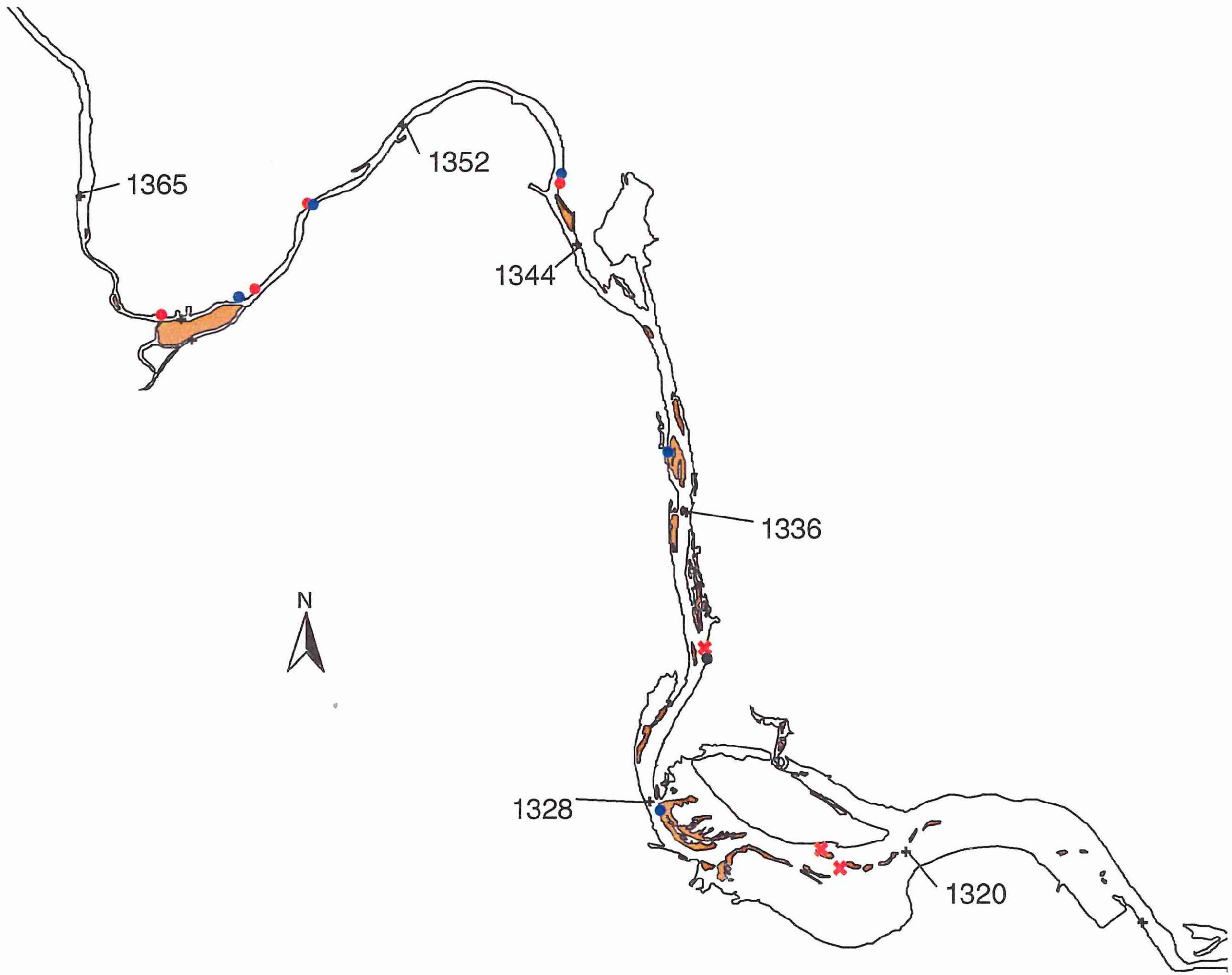

Figure 6. Locations during fall of radio-tagged sauger (✖ = November) and walleye (• = September, • = October, and • = November). No sauger were located during September or October. Numbers associated with the cross (✚) symbol indicate the distance, in kilometers, upstream from the confluence with the Ohio River. Note that some points may reflect multiple locations of individual fish.

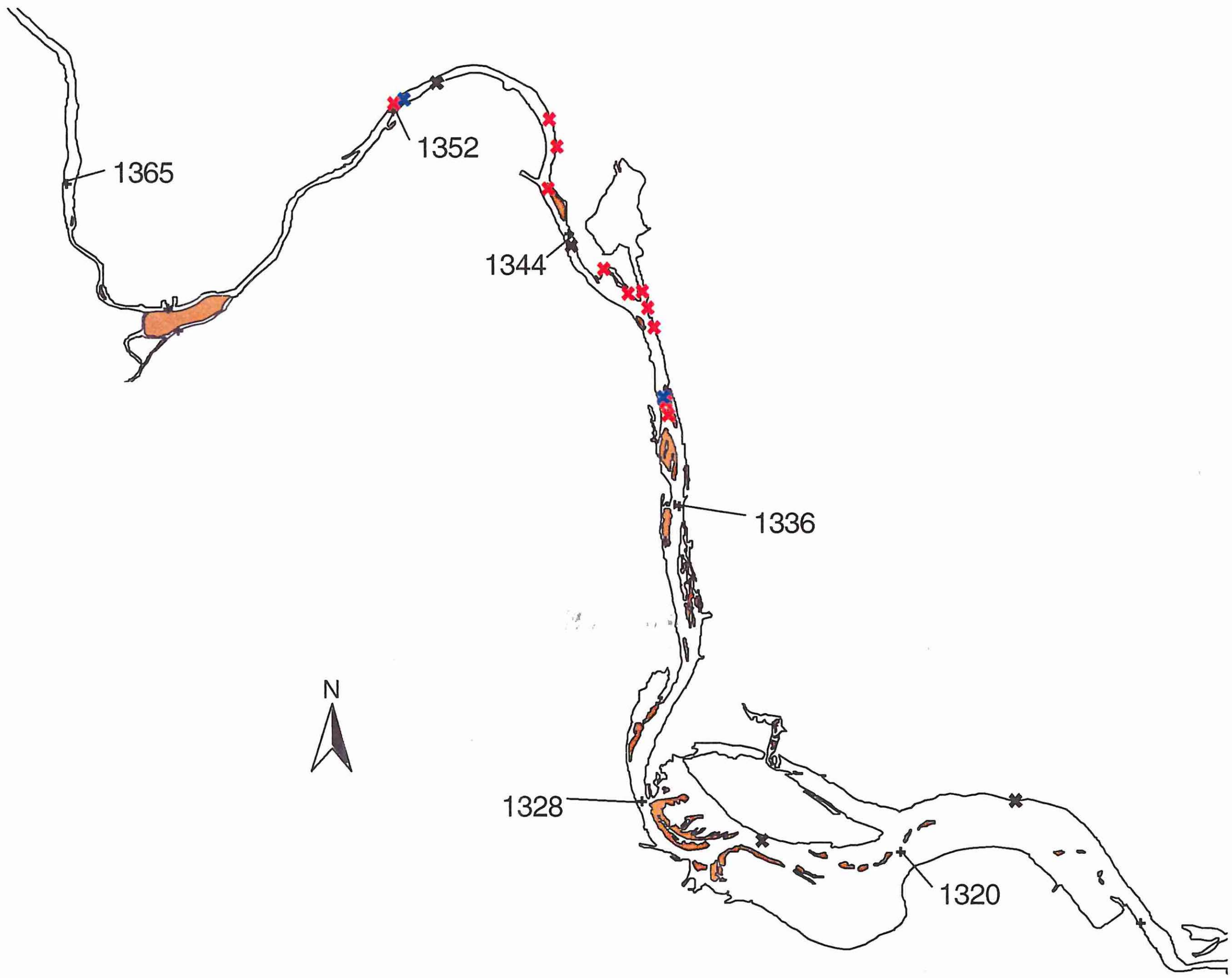

Figure 7. Locations during winter of radio-tagged sauger (✖ = December, ✖ = January, and ✖ = February). Numbers associated with the cross (✚) symbol indicate the distance, in kilometers, upstream from the confluence with the Ohio River. Note that some points may reflect multiple locations of individual fish.

confluence of the Minnesota and Mississippi Rivers in 1999 was 74 km (walleye 731; 19 April 1999). Locations of walleye in the Minnesota River occurred exclusively during the spring period for both years. All walleye located in the Minnesota River during spring both years were subsequently located in Pool 2 at various other times of the year.

Four walleye were located within the area 6 km downstream of Lock and Dam 1 throughout Spring 1998 (Figure 8). Walleye 150, 720, 801, and 871 were tagged in the tailwaters below Lock and Dam 1 near the mouth of Minnehaha Creek on 15 October 1997. They remained in the area throughout much of the spring of 1998. During late spring/early summer 1998, individual movements of these fish increased, eventually leading to the disappearance of walleye 150 and 871, and the mortality of walleye 801. Walleye 720 was located in Upper and Middle Pool 2 until last contact on 20 October 1998.

Summer walleye locations varied between fish. Seven walleye were located regularly during Summer 1998 in Lower Pool 2 (Figure 9). These locations were generally in backwater areas such as Grey Cloud Slough (walleye 130, 490, 590, and 811), Baldwin Lake (walleye 310), the area upstream of Lock and Dam 2 (walleye 731), and main channel border areas near upper Grey Cloud Island (walleye 811). Four walleye were located regularly during Summer 1998 in Middle Pool 2 (Figure 9). Two of these fish (walleye 410 and 951) spent the summer within 3.5 km downstream of the confluence of the Minnesota and Mississippi rivers. The other two fish (walleye 790 and 851) were located repeatedly near downtown St. Paul, between river kilometers 1344 and 1347. Walleye 690 was located in Pool 3 (Figure 9), immediately downstream of Lock and Dam 2, in late spring and throughout summer 1998. This was the only fish located in Pool 3 during this study.

Similar to sauger observations, fall walleye locations were few due to equipment problems during this period. Fall 1998 walleye locations were generally not different from summer locations for walleye 410, 790, and 951 (Figure 6). There was a slight upstream trend in locations for walleye 490 (Figure 6). Its last summer location was 12 June 1998 near Grey Cloud Slough. On 15 September 1998, it was located near downtown St. Paul, a distance of approximately 25 km upstream from its previous location.

Winter walleye locations were predominantly in Middle Pool 2 (Figure 10). Four walleye (walleye 310, 731, 790, and 811) were located regularly during the winters of 1997-98 and 1998-99. Walleye 310 was located during both winter periods close to its tagging site near upper Grey Cloud Island. Walleye 731, 790, and 811 were located during both winter periods near downtown St. Paul.

Spawning Areas

Radio-tagged fish were located frequently during April 1998 near the mouth of Minnehaha Creek. This observation was supported by reports of anglers catching walleye in or near Minnehaha Creek that were streaming gametes. Radio tagged walleye and sauger were also located during April 1998 and 1999 near wing dams throughout Pool 2, particularly those near major tagging sites in St. Paul. Unsuccessful attempts were made to sample walleye and sauger eggs using an epibenthic sled in 1998 and dip nets in 1999.

We deployed sixteen drift nets during April 1999 in four areas (Figure 11). Netting was conducted from 6-28 April 1999. Nets 1-5 were set at the mouth and in the channel of Minnehaha Creek. Nets 6, 7, and 8 were set along a riprapped shoreline downstream of the confluence of the Minnesota and Mississippi Rivers. Nets 9-12 were set on or directly below wing dams near St. Paul. Nets 13-16 were set along riprap shorelines near South St. Paul. Flow rates and depth were high during this period, often submersing net-location markers (floats).

Eggs were collected in nets 2, 3, 4, 5, 6, 8, 10, 15, and 16. The largest number of eggs were collected in Upper Pool 2, in nets 4 and 5 near Minnehaha Creek. A total of 328 eggs were collected. Eighty-five percent of the total eggs were collected near Minnehaha Creek, with one net (5) producing 164 eggs. Thirteen percent of the total eggs were collected below the confluence of the Minnesota and Mississippi

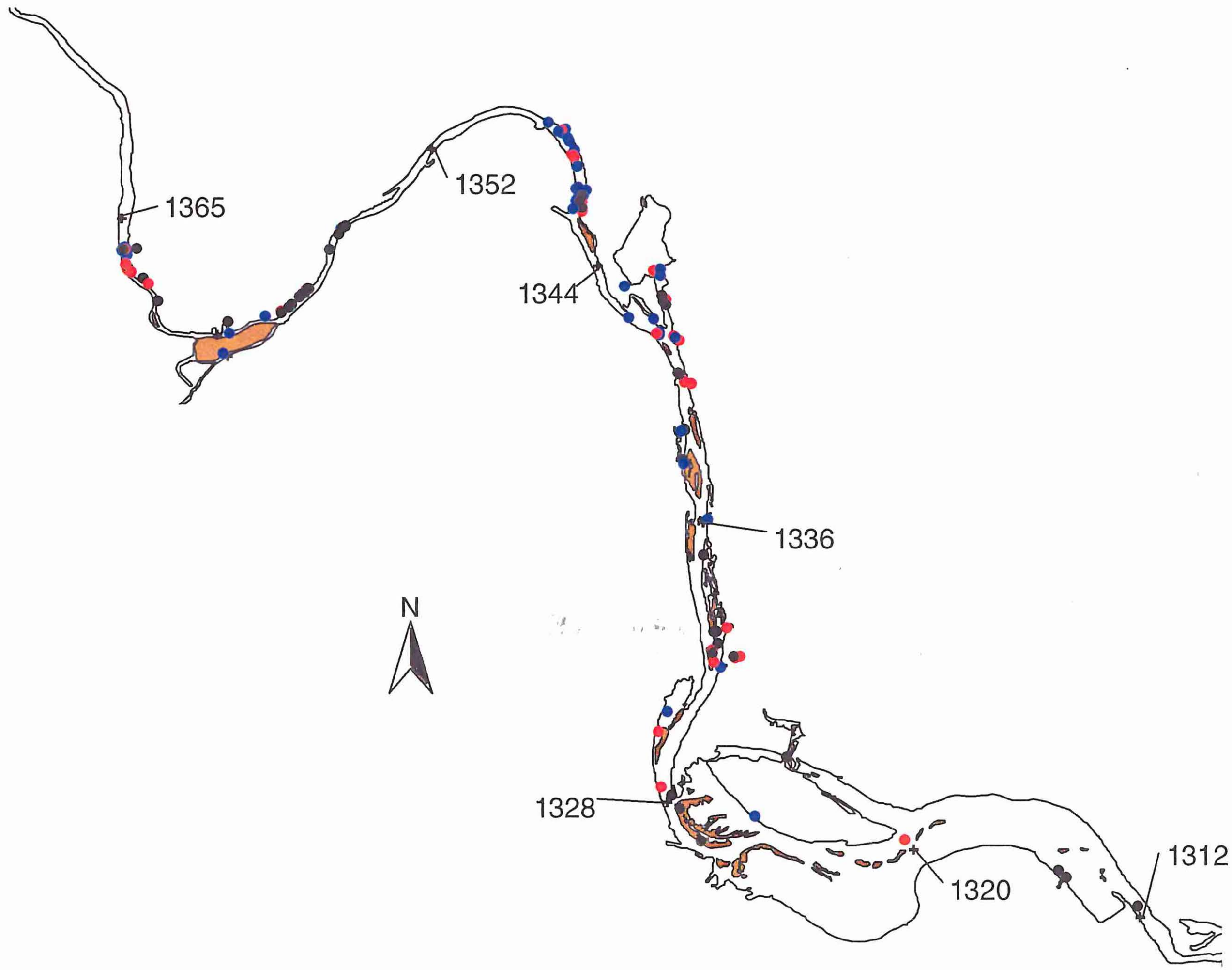

Figure 8. Locations during spring of radio-tagged walleye (• = March, • = April, and • = May) in Pool 2. Numbers associated with the cross (✚) symbol indicate the distance, in kilometers, upstream from the confluence with the Ohio River. Note that some points may reflect multiple locations of individual fish.

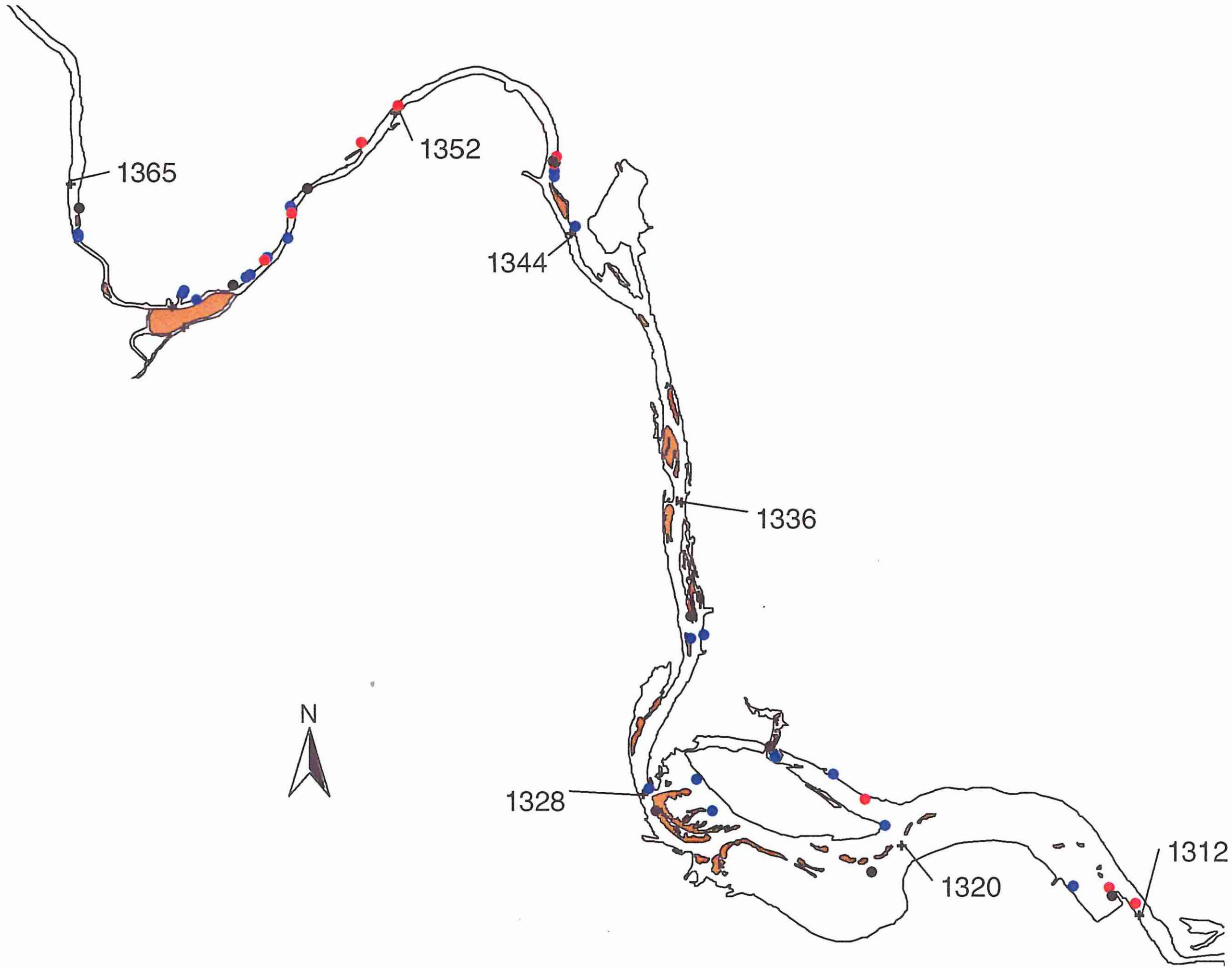

Figure 9 Locations during summer of radio-tagged walleye (• = June, • = July, and • = August) in Pool 2. Numbers associated with the cross (✚) symbol indicate the distance, in kilometers, upstream from the confluence with the Ohio River. Note that some points may reflect multiple locations of individual fish.

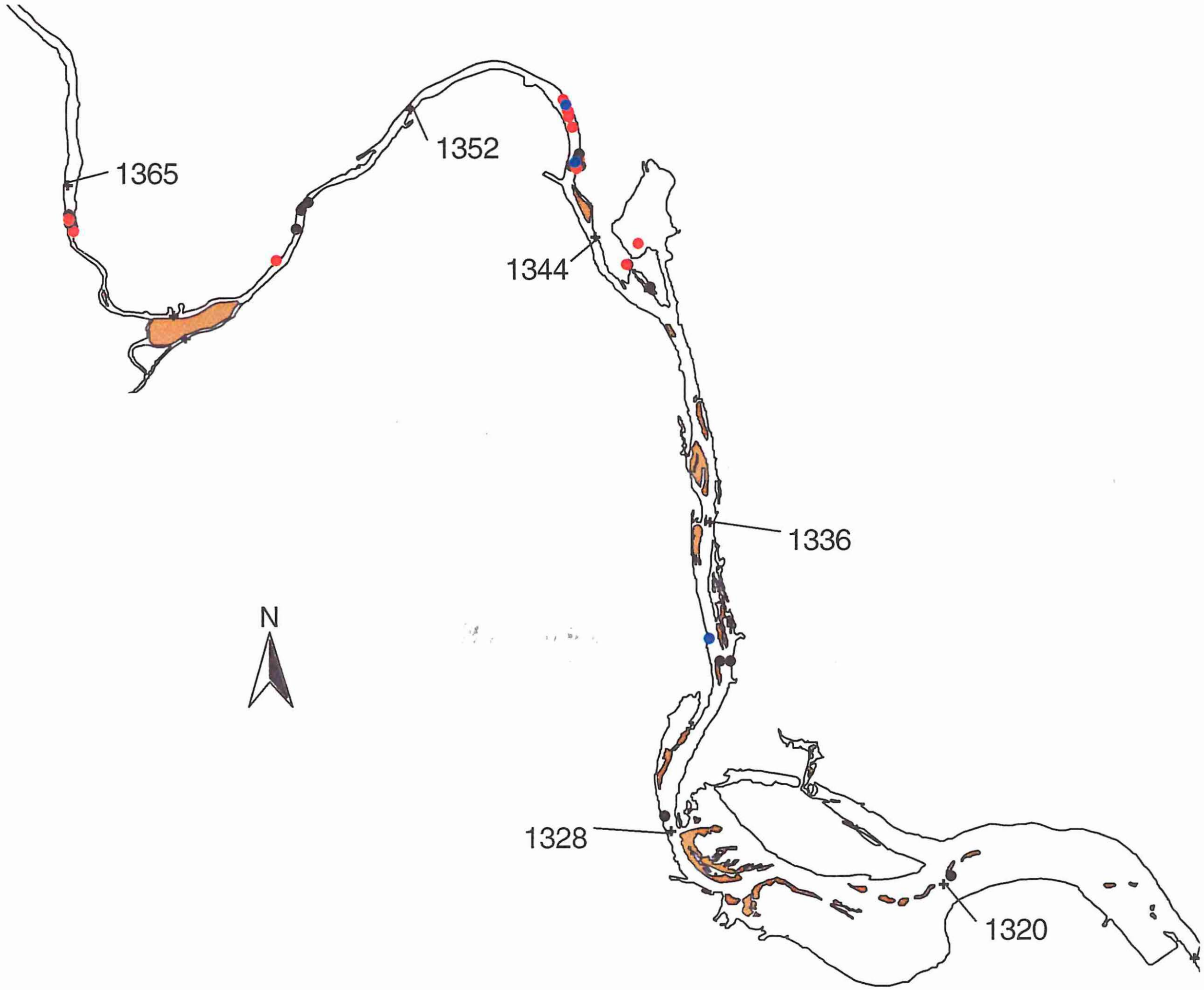

Figure 10. Locations during winter of radio-tagged walleye (• = December, • = January, and • = February) in Pool 2. Numbers associated with the cross (✚) symbol indicate the distance, in kilometers, upstream from the confluence with the Ohio River. Note that some points may reflect multiple locations of individual fish.

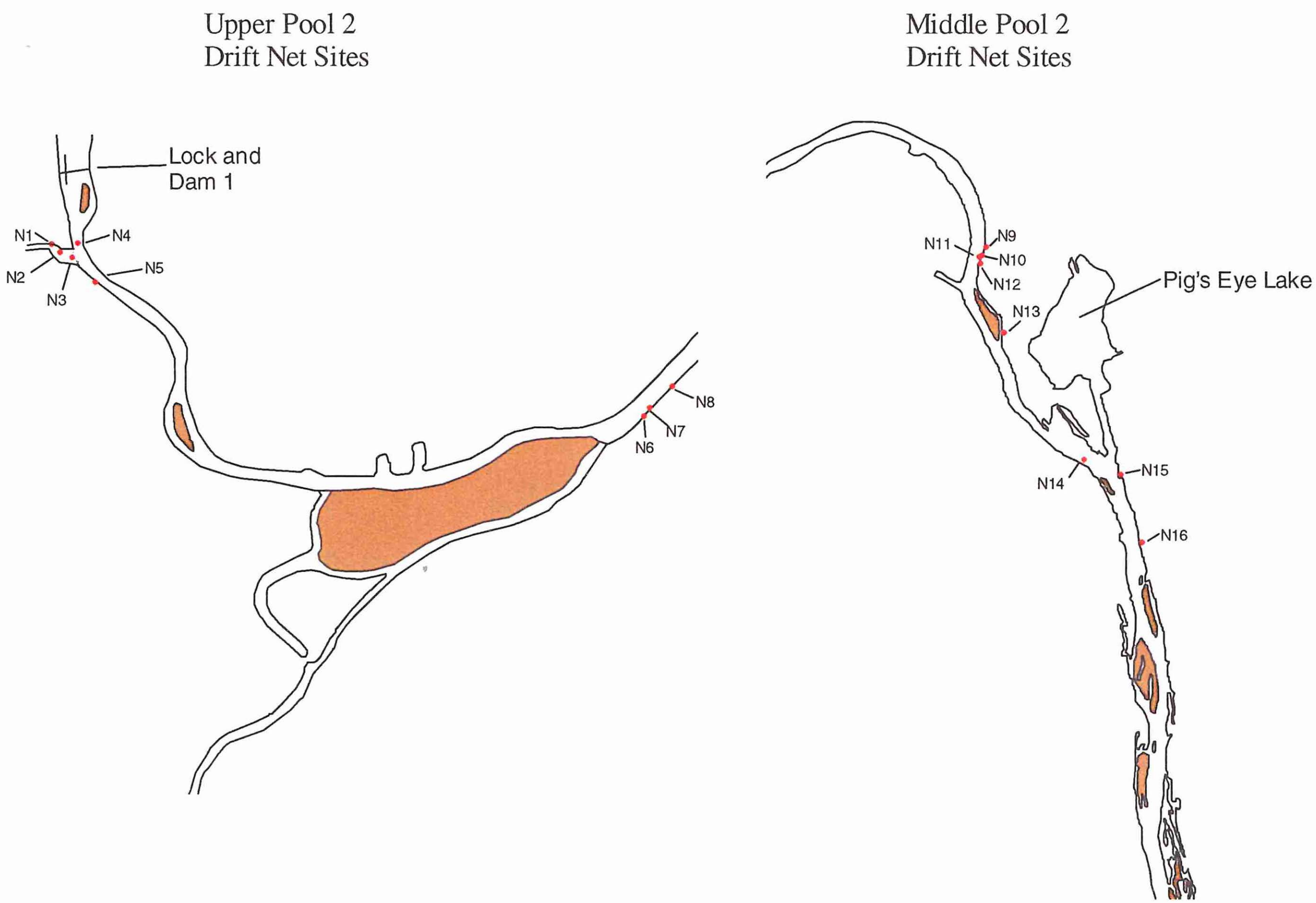

Figure 11. Net sites for sampling drifting walleye and sauger eggs in Upper and Middle Pool 2 of the Upper Mississippi River, spring 1999.

rivers. The remaining 2% came from areas downstream, near St. Paul (1 egg) and South St. Paul (4 eggs). Of the 328 eggs collected, 213 hatched and were identified. All larvae were walleye (193), Hiodontidae (12), Cyprinidae (1), Catastomidae (6), and Esocidae (1). Ninety-eight percent of the walleye were from the Minnehaha Creek area. Other areas that each produced a single walleye egg were: the Minnesota-Mississippi rivers confluence, the St. Paul area, and the South St. Paul area. All percid eggs were relatively uniform in size, in the 1.8-2.2 mm range. Scott and Crossman (1973) reported that walleye eggs are 1.5-2.0 mm, with sauger eggs being smaller. Hatched larvae matched descriptions of myomere counts and pigmentation of walleye presented by Auer (1982) and Holland-Bartels et al. (1990). The presence of adult walleye, determined by radio telemetry or reports by anglers, supported the conclusion that walleye spawning took place in these areas.

Habitat Use and Population Assessment Sampling Efficiency

Due to hydrology, river stage, and limitations in available personnel, no attempts were made to quantitatively describe available habitat. Mean water depth used by sauger was greatest during winter (3.9 m) and spring (3.7 m) (Table 5). Mean water depth was lowest for sauger located during summer (1.4 m). The summer mean water depth was significantly lower than winter and spring. Mean water depth for sauger located during fall (2.8 m) was not significantly different from winter, spring, or summer. Mean water depth for tagged walleye did not differ significantly by season (Table 5). Significant differences between walleye and sauger mean water depth were detected during spring and summer (Table 5). Mean water depth for sauger was greater than walleye during spring (p-value < 0.001) and less than walleye during summer (p-value $= 0.0012$).

We located sauger primarily over sand and silt substrates (Figure 12). Walleye used a wider variety of substrate types than sauger (Figure 12). Similar to sauger, sand and silt were the dominant substrate types used by walleye. However, tagged walleye were located near gravel and cobble substrates more frequently than sauger.

Macrohabitat use by walleye and sauger was similar overall, with the exception of walleye being located more frequently in tailwater areas than sauger (Figure 13). Sauger were located in the main channel 30% of the time. They were located near wing dams or channel borders 25% and 23% of the time, respectively. Walleye were located most frequently near channel borders (25%), the main channel (23%) or near wing dams (23%). The difference between walleye and sauger use of tailwater areas is likely due to the five walleye tagged and subsequently located in the tailwater

Table 5. Seasonal mean water depths of sauger and walleye in Pool 2 of the Mississippi River, 1997-99. Values expressed are the sample size (N) and mean water depth (m), with the standard deviation (SD) in parentheses. Habitat variables with common superscript letters are not significantly different by season, within that species, based on Tukey-Kramer HSD paired comparisons tests. The significant difference row indicates whether there was a significant difference in mean water depth between species during a particular season, based on the results of Wilcoxin Rank Sums tests. Alpha = 0.05 was used for both tests.

	Winter		Spring		Summer		Fall	
	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)
Sauger	7	3.9 (1.4)^{a}	37	3.7 (1.1)^{a}	12	1.4 (1.0)^{b}	3	2.8 (0.9)^{ab}
Walleye	23	3.4 (1.4)^{a}	95	2.8 (1.1)^{a}	33	2.7 (1.2)^{a}	10	3.0 (1.2)^{a}
Significant difference?		No		Yes		Yes		No

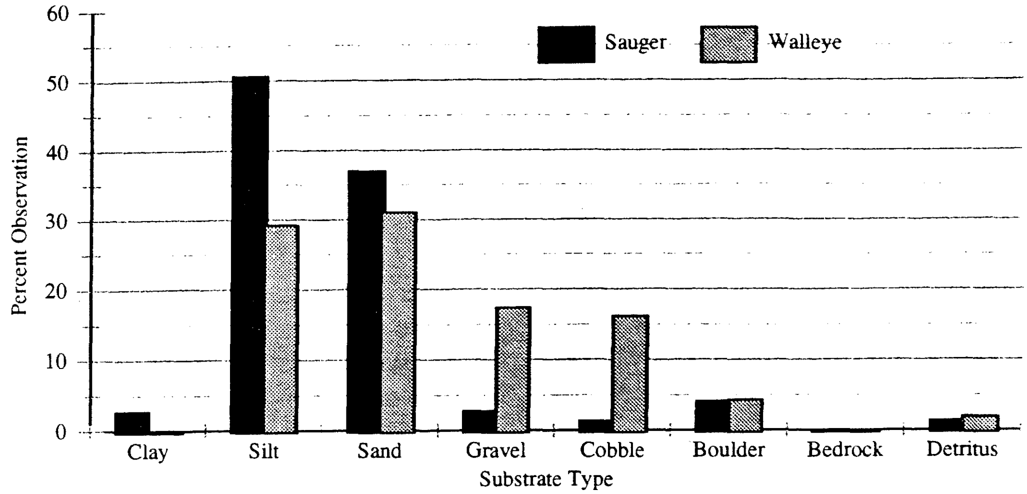

Figure 12. Summary of substrate types at locations of radio-tagged sauger and walleye in Pool 2 of the Mississippi River, 1997-99.

of Lock and Dam 1, since no sauger were tagged in this area. Walleye primarily used channel borders, wing dams, and the main channel during winter, spring, and fall (Figure 13). During summer, walleye used wing dams, backwaters, and the main channel (Figure 13). Sauger primarily used wing dams, the main channel, and channel borders during winter and spring (Figure 13). During summer, sauger used backwater areas much more frequently than other areas (Figure 13).

We used telemetry results to choose sampling stations to increase electrofishing sampling efficiency as needed for population assessment. The first sampling period occurred during late fall 1998 and consisted of four sampling events. Sampling was performed downstream of Lock and Dam 1, and on or near wing dams in Middle Pool 2. Electrofishing catch-per-unit-effort (CUE) during this time ranged from 12-61 fish per hour, with an overall mean CUE of 37 fish per hour. Due to ice formation in Lower Pool 2, only Upper and Middle Pool 2 were sampled during the fall period. The second sampling period occurred during June 1999 and consisted of three sampling events. Sampling was performed in backwater areas of Lower Pool 2, and below Lock and Dam 1. Water levels were too high to sample wing dam habitat previously sampled in Middle Pool 2. Thus, only Upper and Lower Pool 2 were sampled during spring 1999. CUE for the spring sampling period ranged from 5.5 - 74.5 fish per hour, with an overall mean of 29.8 fish per hour. The highest CUE for each period was observed in the area downstream of Lock and Dam 1. During fall, catch rates were also high in middle Pool 2 during the second sampling event (51.3 fish per hour), and subsequently declined on the last two fall sampling dates (17.3 and 12 fish per hour, respectively). While spring electrofishing in the Lock and Dam 1 tailwaters resulted in high catch rates (74.5 fish per hour), catch rates in Lower Pool 2 were much lower (5.5 fish per hour).

Discussion

Seasonal Movements

Sauger were generally more difficult to locate than walleye because radio signals attenuate with increasing water depth (Winter et al. 1978). The *a priori* belief was that the water depth throughout the majority of Pool 2 corresponded to the 2.7 m navigation channel, with a limited number of areas where the depth was greater than 9 m. It was also believed that the

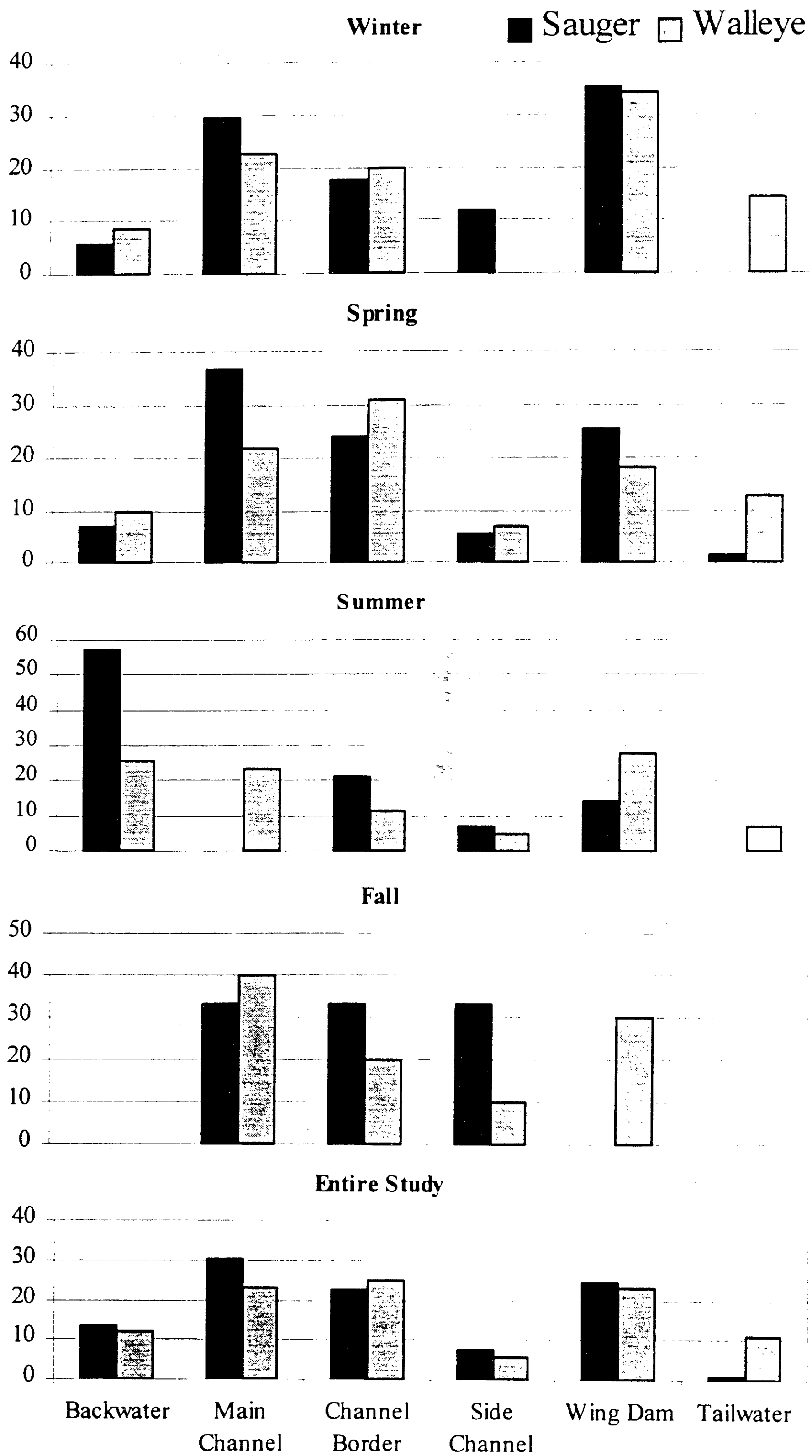

Figure 13. Macrohabitat use summary for radio-tagged sauger and walleye during winter, spring, summer, fall, and throughout the entire study period.

radio transmitters would be effective in water depths up to 7-9 m. However, personal observation indicated that the amount of water deeper than 9 m is more prevalent than previously assumed, particularly during periods of high runoff. Furthermore, the maximum depth at which any fish was located was 6.7 m. This indicates that difficulties locating fish, particularly sauger, may have been due to equipment limitations related to water depth. Therefore, caution must be used when interpreting data from this study, especially mean depth used, as it is likely biased to favor fish that were located in shallow water.

Sauger and walleye tagged with radio transmitters in Pool 2 exhibited variable and complex movement patterns. Spring walleye and sauger movement up the Minnesota River in 1998 and 1999 comprised the most significant movements of the study. Fish were found in the Minnesota River beginning in mid-March and continuing until late-April or early-May. Due to the timing of the movement, it was likely related to spawning activity for both species. However, no effort was made to document spawning outside of Pool 2. Several studies have documented upstream movements related to spawning for both walleye and sauger (Holzer and Von Ruden 1984; Freiermuth 1987; Pitlo 1989; Siegwarth 1993). Walleye and sauger locations in the Minnesota River were not numerous enough to make accurate conclusions on the distance traveled or total time spent outside of Pool 2. The extreme upstream locations of sauger and walleye were 90 and 73 km, respectively, from the confluence of the Minnesota and Mississippi Rivers, and indicate that fish traveled long distances during these periods.

Water flow in the tailwaters of Lock and Dam 1 exposes rock and gravel substrate for several kilometers downstream, making it ideal habitat for demersal spawners like sauger and walleye. Freiermuth (1987), Bulow et al. (1991), and Brooks (1993) documented sauger spawning in dam tailwater areas. Paragamian (1989) located walleye spawning in tailwater areas in the Cedar River. In a study similar to the present one, Ickes et al. (2000) found sauger spawning in the area downstream of Lock and Dam 3, the same area identified by Freiermuth (1987). Therefore, one might expect migrating walleye and sauger to travel past the confluence of the Minnesota River up the Mississippi River to move into tailwater areas, taking advantage of the habitat located there. Furthermore, water quality is typically lower in the Minnesota River, due to the high levels of suspended solids. Nonetheless, no observations were made of walleye or sauger moving into the tailwater areas from downstream areas during spawning.

All long-distance upstream movements by both species involved the Minnesota River. Several hypotheses have been formulated to explain this observation. One hypothesis is that fish move into the Minnesota River to use smaller tributaries to spawn. Siegwarth (1993) found that both walleye and sauger used a tributary of the Mississippi River to spawn. Ickes et al. (2000) found walleye traveled a substantial distance from Pool 4 up the Vermillion River during spawning periods. Another possible hypothesis is that walleye and sauger use alternative habitats for spawning. Pitlo (1989) documented walleye spawning on mussel beds, which are present in the Minnesota River. Priegel (1970), and Holzer and Von Ruden (1984) found walleye spawning in flooded marsh areas over submerged vegetation. Ickes et al. (2000) found that walleye in Pool 4 used flooded backwaters for spawning when water levels were high enough to allow entrance to these areas. The timing of fish movements into the Minnesota River from Pool 2 corresponded to high spring flows. During these periods, flooded backwaters with submergent vegetation were common. Two walleye were located in such backwater areas, one in 1998 and one in 1999.

One concern of local fishery managers prior to this study was that fish protected under the catch and release only restriction for Pool 2 were leaving the pool and subjected to harvest. While this is a possibility, we found no evidence of this occurring. The major movement of fish into the Minnesota River occurred during the period when the angling season for game fish is closed. Rapid movements back downstream indicate that all radio tagged fish located in the Minnesota River had returned to Pool 2 by the time the harvest season opened. Only one sauger (#660) was located in the Minnesota River after the fishing season opened in 1998.

However, this fish was believed to be dead, and may have died prior to the fishing season opener.

Holzer and Von Ruden (1984) observed distinct individual movement patterns of walleye tagged in Pool 8 of the Mississippi River. Similar observations were made on walleye during this study. While many fish traveled long distances up the Minnesota River, several others exhibited contrary behavior, and didn't venture far from their original tagging sites. One walleye (#790) remained within 0.8 km of its tagging location from 16 October 1997 until contact was lost in December 1998. This fish remained near wing dams during the entire period, and was caught and released once by an angler. Only walleye were tagged near Lock and Dam 1 and didn't move significantly until early summer 1998. Several sauger exhibited downstream movement during spring 1998. However, locations for these fish were very infrequent and the extent of these movements could not be documented.

Summer contacts of walleye and sauger were made predominantly in Lower Pool 2. Both walleye and sauger used a combination of main channel border/backwater lake habitat during this period. Fish located in backwaters were found in depths as shallow as 0.3-0.7 m (sauger 670, walleye 731). Several walleye also used wing dam areas and main channel areas downstream of the confluence of the Minnesota and Mississippi Rivers, consistent with the findings of Pitlo (1983) for walleye in Pool 13. He also documented sauger using sloughs and side channels, though wing dam and main channel border were used more frequently during this period.

Due to high catch rates of walleye and sauger by anglers in Middle Pool 2 during the winter, fishery managers have suspected that these species use that area for staging prior to spawning movements. The results of this study reinforce that conjecture. The majority of walleye and sauger locations during winter were observed in Middle Pool 2. Several fish (e.g. walleye 731 and 811, sauger 781) that were commonly located in Lower Pool 2 during summer were located numerous times in Middle Pool 2 during winter.

Despite attempts to locate fish in Pool 1, Pool 3, and the St. Croix River, only one fish was located outside of Pool 2 in areas other than the Minnesota River. This was a walleye located in the tailwaters of Lock and Dam 2. Depth limitations of radio-telemetry may have prevented us from locating other fish outside of Pool 2.

Spawning Areas

Walleye eggs were collected from all major netting sites and hatched. Most walleye eggs were collected near the mouth of Minnehaha Creek, in the tailwater area of Lock and Dam 1. This area had been postulated as a spawning area, due to large amounts of spawning habitat and reports of anglers catching spawning walleye in this area. Thus, the area immediately downstream of Lock and Dam 1 is considered a primary walleye spawning area. Small numbers of walleye eggs were collected below the confluence of the Minnesota and Mississippi Rivers, on wing dams near downtown St. Paul, and from the main channel border habitat in the South St. Paul area. It is impossible to determine whether these eggs were distributed nearby, or whether they had drifted from further upstream. Pitlo (1989) collected viable eggs as far as 0.9 km downstream of spawning areas. He also concluded that eggs may drift much farther, even incubating while drifting. However, these areas were chosen as suspected spawning areas based on the presence of radio-tagged fish and reports of anglers catching ripe fish. It is reasonable to conclude that spawning did occur nearby upstream of the nets, though exact spawning areas were not precisely located. Eschmeyer (1950) and Johnson (1961) reported walleye spawning on small, discrete patches of gravel and rubble, while avoiding sand. Varying locations of walleye and sauger during spawning periods in Pool 2, combined with small numbers of eggs collected, suggest that spawning within the pool may occur in small events wherever suitable habitat is present. Wing dams are prime candidates for walleye and sauger spawning areas due to large amounts of firm or rocky substrates. No sauger eggs were collected during this study, and is likely due to the inability to locate sauger spawning sites. Sauger spawning has been reported at depths of 3-7.3 m, along the main river channel (Medlin 1990;

Brooks 1993). Spawning in Pool 2 may have occurred at similar locations, however, depth limitations of our radio-telemetry gear may have inhibited our ability to locate these fish and sample drifting sauger eggs.

Habitat Use and Population Assessment Sampling Efficiency

The ability to effectively sample walleye and sauger populations in Pool 2 is important for evaluating the catch-and-release-only regulation and for population assessment. One objective of this study was to gain insight on the behavior of these species to increase sampling efficiency. Movements and habitat use were evaluated to determine whether certain areas or microhabitat types could be targeted to produce reliable samples. Substrate use by tagged walleye and sauger was not related to season. Sauger used mainly sand or silt substrates, which are very abundant in the main channel and slack water areas. Walleye used rocky or gravel substrates more frequently than sauger. In Pool 4, Ickes et al. (2000) found mean sauger depth was significantly greater than mean walleye depth during all seasons except summer. In the present study, we found that water depth differed significantly only during spring and summer, with sauger using deeper water in the spring and walleye using deeper water in the summer. Water depths used by tagged fish may provide the most insight for planning sampling efforts. For both species, mean water depth used was lowest during summer and highest during winter. Use of shallow water by walleye and sauger during summer may be a benefit when electrofishing gear is the preferred sampling method. However, walleye and sauger located in these areas appeared to exhibit roaming behavior and did not relate to particular structure or shorelines. Electrofishing is most successful when fish concentrating structures, such as shorelines, riprap, or submerged trees, are targeted. Thus, electrofishing may not be the most effective method for sampling backwaters.

We analyzed macrohabitat use by walleye and sauger to determine what types of habitat could be most efficiently sampled at various times of the year. Main channel and channel border habitat are frequently used by walleye and sauger during winter, spring, and fall. However, sampling these habitat types is difficult. Water depth in the main channel and channel borders is typically too deep to sample with electrofishing gear. Furthermore, high water flow rates, navigational use, and floating debris restrict the use of nets in these areas. Sauger and walleye both used backwater areas during the summer. Since flow, floating debris, and navigational use are much less in these areas, trap netting or gill netting may be a productive method for sampling backwaters. Walleye frequently used tailwater areas. The highest percentage of tailwater use occurred during winter and spring. The tailwater area below Lock and Dam 1 has extensive rocky and rip-rapped shoreline, including an island directly below the dam. Just below the tailwater area is the mouth of Minnehaha Creek. Walleye anglers from boat and shore typically have highest catch rates in this area during winter and spring. Electrofishing may be a successful method of sampling these areas during this time. Another macrohabitat candidate for increasing sampling success may be wing dams. Wing dams were used by walleye and sauger during all seasons. Likewise, walleye and sauger anglers typically have high success rates by targeting wing dam areas. Wing dams are an important component of available habitat to fish populations in the Mississippi River, providing various fish species with shelter, food organisms, and spawning substrate (Pitlo 1998). Thus, wing-dam sampling may be useful and should be investigated further by Pool 2 managers. Pitlo (1998) summarized and compared the results of several studies of evaluating gear for sampling fish populations from wing dams. Trammel nets, hoop nets, gill nets, frame nets, and electrofishing were compared. All methods were effective in sampling these areas, with some methods performing better in collecting certain fish species than others. Electrofishing typically outperformed other gears, displaying the highest CUE and the largest number of species sampled. Pitlo (1998) also noted that entanglement gear was prone to reduced efficiency during periods of high flow, when gill nets and trammel nets became plugged with debris.

In the present study, electrofishing during fall 1998 produced high catch rates of walleye. Habitat sampled included shallow rocky areas in the tailwater of Lock and Dam 1, and backwater and wing dam habitat in Middle Pool 2. Electrofishing in spring 1999 again produced high catch rates in the Lock and Dam 1 tailwaters. However, efforts to sample walleye and sauger in Lower Pool 2 were largely unsuccessful. Fishery managers have indicated that the best electrofishing success in Lower Pool 2 depends largely on weather conditions (e.g., windswept shorelines). Electrofishing effort in the future should be intensified, sampling various habitats during different seasons to determine which combination of season and habitat yields the most reliable results. Consideration should also be given to other sampling methods, such as frame nets or trammel nets.

Management Implications

Seasonal movement patterns of walleye and sauger indicated that the majority of movements outside of Pool 2 took place in the Minnesota River, during the period of time when the harvest season is closed for these species. Based on this, one may conclude that Pool 2 walleye and sauger are being protected by a year-round catch and release only regulation.

Telemetry was successful in identifying some areas that may be important for walleye and sauger spawning. Egg sampling verified walleye spawning in Upper Pool 2. Since spawning may be occurring at other locations, any future effort should be directed at locating and describing spawning areas in Lower Pool 2, particularly for sauger. Wing dams may be the best candidates for good spawning habitat, and should be examined further.

Seasonal variations in sampling success for walleye and sauger exist in Pool 2. Our two sampling periods indicate that high sampling success may be observed during the fall over wing dams. This may be due to behavior of the fish, or it may simply be due to low water levels during this period contributing to increased success with electrofishing gear. Sampling success in Lock and Dam 1 tailwaters was high during spring and fall. To get the best estimates of true population parameters for Pool 2 walleye and sauger, samples should be taken from various portions of the pool. To develop the most efficient sampling plan, more intensive sampling should be done on an experimental basis. Electrofishing should be performed in various suitable locations during all seasons to determine which combination of season and location provides the best sampling plan. Consideration should also be given to using passive capture gear, such as frame nets or gill nets, to sample areas that are not suitable for electrofishing.

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