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ABSTRACT

Nebraska Public Power District (NPPD) has monitored fish populations annually (except 1998) since 1993 on the Niobrara River in Nebraska, in the vicinity of Spencer Hydropower Project before and after "flushing" or "sluicing" activities. These activities could alter water quality in the river downstream, which can negatively impact fish populations. Intensive sluicing-monitoring studies coupled with operational adjustments indicated minimal impacts were occurring to fish populations in the vicinity of the hydro. Long-term diversity and abundance of fish species has been a historical concern, so annual fish sampling has continued through the present. Of the 13,063 fishes in 26 species sampled below the hydropower complex, six species composed approximately 96.5 percent of the total sample. The most common species sampled were sand shiner, *Notropis ludibundus* (38.6%); red shiner, *Notropis lutrensis* (34.0%); flathead chub, *Hybopsis gracilis* (12.2%); carpsuckers, *Carpiodes spp.* (5.6%); bigmouth shiner, *Notropis dorsalis* (3.9%); and channel catfish, *Ictalurus punctatus* (2.2%). Over the nine-year period, catch-per-unit-effort trends indicated no significant increases or decreases among years sampled and the respective species collected. Fish CPUE was not significantly affected by short-term annual sluicing.

† † †

Nebraska Public Power District (NPPD) owns and operates the Spencer Hydropower Project ("the hydro") on the Niobrara River, approximately 8 km south of Spencer, Nebraska, on the Holt and Boyd County line (Fig. 1). The river, with headwaters in eastern Wyoming, flows approximately 800 km eastward across Nebraska, joins the Missouri River near Niobrara, Nebraska, and drains a watershed of approximately 28,000 km^2.

The hydro project structure (Fig. 2) was installed in 1927 and at that time consisted of (1) a 1,200-acre reservoir; (2) a short concrete abutment on the north and south banks of the river; (3) a powerhouse containing two generators (2,000 kW and 1,300 kW); (4) a spillway with a combination gate bay consisting of four tainter gate bays, five stop log bays, and a sluice gate; and (5) a 3,700-foot long, 18-foot high earth embankment. NPPD conducts sediment-flushing activities (sluicing) to remove accumulated sediment from the reservoir above the hydro in the spring and fall. Sluicing was historically conducted several times a year dating back to 1948 (Mares 1991). During sluicing, four tainter gates and a sluice gate are typically opened for about a week to essentially drain the reservoir, while flow continues through the facility. Fish in the Niobrara, however, are adapted to highly turbid, variable sediment (sand) conditions. It is estimated that the river transports more than 300 metric tons of sediment per day in this reach of the river (Hotchkiss et al. 1993).

Between 1975 and 1989, periodic fish-kills were observed below the hydro during sluicing. Fish were particularly vulnerable to sluicing in summer, during low flows and high water temperatures. Previous investigators, such as Hesse and Newcomb (1982), studied fish populations in the vicinity of the hydro and expressed concern about its impacts. In 1980 a management variance was drawn up by NPPD and the Nebraska Department of Environmental Control (NDEC now NDEQ, Nebraska Department of Environmental Quality) and the Nebraska Game and Parks Commission (NGPC), stating that NPPD avoid sluicing between April 15 and September 15 each year, except for emergencies, to minimize impact on the riverine fisheries during that time. The variance no longer exists, and changes in Title 117, Nebraska Surface Water Quality Standards, reflect this change. All sluicing has been conducted between September 15 and April 15 since 1993. The only exception was August, 1999.

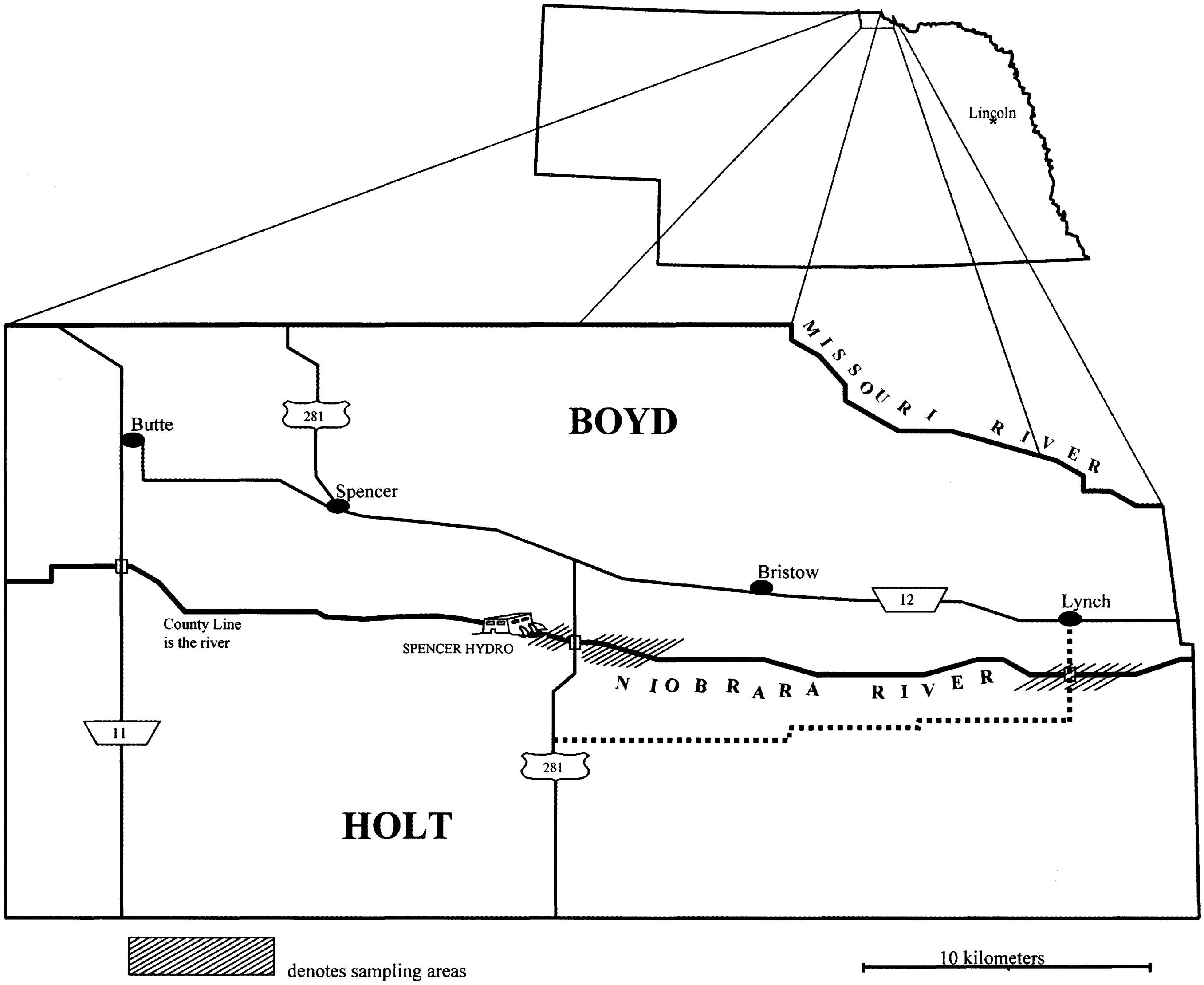

Figure 1. Spencer Hydro study area in Boyd and Holt counties, Nebraska.

We were interested in evaluating fish populations below the hydro to establish data regarding fishery populations and related long-term impacts, particularly in the fall, when conditions can be deleterious to riverine biota. The objectives of this study were to determine species composition below the hydro to discover whether the hydro operation was in any way impacting fish species richness on the Niobrara River and to see if any discernable trends could be noted in the species that were sampled.

METHODS

Fish sampling

Sampling was conducted each fall from 1993 through 2001, except no sampling was done in 1998. All fish were sampled by seining and electrofishing within 1.5 km below the hydro (above and below the Highway 281 bridge) and at locations above and below the Lynch bridge, approximately 6 km south of Highway 12 near Lynch, Nebraska (Fig. 1). Minimal fish surveys were conducted above Spencer Dam but were not included in this evaluation for long-term trends (Gutzmer et al. 1996).

The seine used was approximately 8 m wide and 1 m high, and the mesh size was 5 mm; haul lengths were 15 m. Sampling occurred before (presluice) and while the gates were open during sluicing (post-sluice). A Smith-Root Model 15-C backpack shocker was used to shock 30.45-m sections of bank habitat. Two dip-nets were used to collect fish. Sampling was done at selected locations (Fig. 1) below the dam, along bank habitats and in some mid-channel habitats that contained shale outcrops or rocky cobble. Initially, in 1993, approximately 10 seine hauls and 10 electroshock segments were sampled above and below the hydro. After 1994 the effort was reduced to accommodate available staff at the time (sampling effort is shown in Table 2). Habitat for seining and electroshocking was fairly

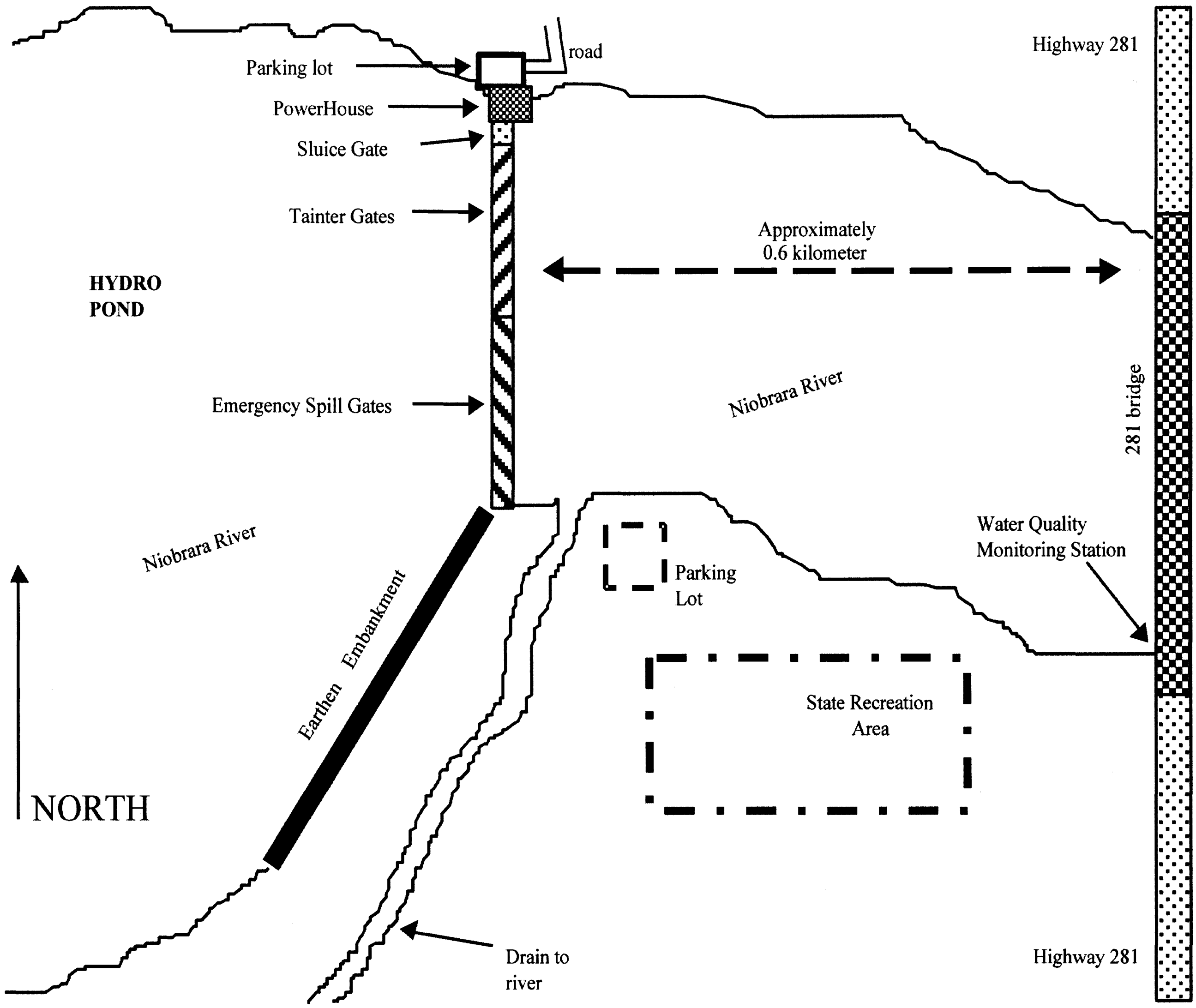

Figure 2. Map of Spencer Hydro structures and dam on the Niobrara River.

accessible the first few kilometers below the hydro, and the river widens near the bridge at Lynch and had ample sandbar habitat for seining.

All fish collected from both sampling gears were enumerated and identified to species. Data sets were analyzed statistically using one-way analysis of variance for seining and electroshocking for all nine years of the study period.

Water quality

Water-quality parameters below the hydro during sluicing have been monitored since spring 1989. The parameters monitored were temperature, conductivity, settleable solids, flow volume, and turbidity (as measured by Secchi disc) (Table 1). Temperature and conductivity were evaluated with a Yellow Springs Instrument (YSI) temperature/conductivity meter. In 1993 and 94 settleable solids were determined with a 1,000-ml graduated cylinder, and in 1995–2001 an Imhoff cone (1000 ml) was used. A one-way analysis of variance test was conducted to determine significant differences between years.

RESULTS

Annual fall sampling (Table 2) resulted in 13,063 fishes with 26 species. Over the nine years, the species most observed were the sand shiner, *Notropis ludibundus* (38.6%); red shiner, *Notropis lutrensis* (34%); and flathead chub, *Hybopsis gracilis* (12.2%). The catch-per-unit-effort (CPUE) ranged from 0.467 fish/foot to 3.035 fish/foot for a 9-year calculated CPUE of 0.913. There was no significant difference between years for shocking ($p = 0.4879$), seining ($p = 0.4879$), and total numbers of fish sampled ($p = 0.1164$).

Water quality

Daily water temperatures ranged from 7.5 to 22° C, but generally were the same from 1993 to 2001. Dis-

Table 1. Water-quality parameters during fall fish-sampling below Spencer Hydro, 1993–2001.

	1993	1994	1995	1996	1997	1999	2000	2001
Temperature °C	10.9–16.0	9.6–10.6	8.6–12.2	14.1	18.7	25.7	22	7.5–15.9
Dissolved oxygen	—	—	—	—	9.61	7.62	8.04–8.76	11.06–11.41
pH	—	—	—	—	—	8.9	8.1–8.2	8.5
Secchi disc (cm)	5–20	—	—	15	10	23	25	20–22
Settleable solids (mg/l)	5–25	10–20	<10	3	1.5	<1	0.1	0.05
Conductivity (μohms)	185–190	249–255	177–184	228	244	210	250–320	256
TDS (Total dissolved solids)	—	—	—	—	—	—	133–138	138
Flow (cfs) (Apr.–Sep. mean)	1914	1500	2686	2019	1915	2005	1440	1887

solved oxygen ranged from 7.62 to 11.41 mg/l. The pH values ranged from 8.1 to 8.9, and Secchi disc readings ranged from 5 to 22 cm through all fish samplings. Settleable solids ranged from 0.1 through 25 mg/l. Conductivity ranged from 177 to 320 μ ohms. In the later years of the study, total dissolved solids were measured and ranged from 133 to 138 mg/kg.

Over the nine-year period, April–September flows ranged from 1440 to 2636 cfs, and the average was 1914 cfs (Table 1), indicating relative stability of sandbed prairie streams.

DISCUSSION

The species composition was somewhat comparable to that found in previous studies of the river. Hesse and Newcomb (1982) found that sand shiners composed 88.6%, river shiners 10.3%, and bigmouth shiners 1.1% in the downstream river section, below the hydro.

For 1993–2001, NPPD surveys indicated that sand shiners and red shiners were the most common, at 38.6% and 34%, respectively. Abundances of bigmouth shiners were similar to the Hesse studies, with 5.6% of the total sample. Only one river shiner was documented in our studies, but in the early 1980s they composed 20.1% of the catch. Previous studies indicated only a few river shiners in some incidental spring sampling, and no apparent adults in the fall were identified (Gutzmer et al. 1996). As in the Hesse studies, some species appeared in samples during certain times of the year and not in others, because certain habitats were much more accessible than others. This was especially true above the hydro because high flows, inclement weather, and oftentimes very different habitat types (deeper, marshy, wooded sandbars with intermittent isolated or partially connected meandering streams to the river itself) were common for several kilometers. For purposes of this study, only downstream of the hydro was evaluated for purposes of eliciting any possible barrier/distribution effects or perturbating impacts as a result of sluicing events during this nine-year period.

Among the species identified as sensitive in Title 117, Nebraska Surface Water Quality Standards, is the grass pickerel, *Esox americanus*, which was documented in our collections below the hydro in 1993 and 2000. The yellow perch, *Perca flavescens*, was also sampled in 2001 and was a new addition to the species list. Periodically collected were recreationally important species such as sauger, *Stizeostedion canadense*; largemouth bass, *Micropterus salmoides*; and channel catfish, *Ictalurus punctatus*. Below Spencer Dam is a well-established, recreationally recognized channel catfishery as well as a fall run of sauger that attracts fishermen from across the state.

The CPUE estimate for all years combined was 0.913. There were no significant differences between CPUE for any of the years sampled. There was some flow variation, but not enough to significantly impact sampling success or the populations themselves. It appears that species richness remins relatively stable regardless of any hydro activities related to sluicing, at least in the short term.

The increased sediment load and loss of acclimation time under the low flow/higher water temperature conditions were once thought to be the major causes of the fish kills and could be detrimental to existing fish populations (Gutzmer 1993). The movement of sediment through the flood and sluice gates can also strand fish above and below the hydro due to shifting stream channels and deposited sediment. The tainter and sluice gates were normally opened quickly and the pond drained rapidly during historic operation of the facility. Operational modifications instituted in the early 1990s, such as monitoring and slowing the rate at which the pond is dropped above the hydro, have been effective in reducing fish mortality.

Table 2. Fall sampling abundance, catch per unit effort (CPUE), sampling enumeration, and percent composition of fish on the Niobrara River below Spencer Hydro, 1993–2001. Sn = Seine, Sk = Shock.

	1993		1994		1995		1996		1997		1999		2000		2001		1993–2001	
	Sn	Sk	Sn	Sk	Sn	Sk	Sn	Sk	Sn	Sk	Sn	Sk	Sn	Sk	Sn	Sk	Totals	%
Big mouth shiner	19	15		1	1	5	9		27	2	10	12	158	20	2	5	286	2.20
Black bullhead		1		5		1						1		1			9	0.10
Black crappie		1						1									2	0.00
Bluegill	1	6	1	1		8		6				2		2			27	0.20
Brassy minnow	3	1	1	1							1						7	0.10
Carpsuckers spp.	15	1	13		104	4	89	9	65	3	7	5	383	7	18	10	733	5.60
Channel catfish	3	5	47	14	149	92	5	9	50	32	7	42		6	37	11	509	3.90
Common carp		2	7	7	8			2		9		6	7	1		2	51	0.40
Creek chub														2		8	10	0.10
Longnose dace																1	1	0.00
Emerald shiner		1					2					1	36	25		6	71	0.50
Fathead minnow	77	9	2			1		1				1	8				99	0.80
Flathead chub	3	4	26	35	174	569	166	163	46	84	84	89	11	22	10	103	1589	12.20
Grass pickerel		1												1			2	0.00
Largemouth bass		6		1	2	4		1	1	1	2	2		5	1	7	33	0.30
Red shiner	308	382	93	143	439	80	140	80	797	161	491	127	144	409	303	350	4447	34.00
River shiner															1		1	0.00
Sand shiner	326	165	198	36	831	547	52	109	355	53	364	182	891	489	176	274	5048	38.60
Sauger					1			1								1	3	0.00
Shorthead redhorse		4		4	4	1				2		3		1			19	0.10
Stone catfish					1			1									2	0.00
White crappie		1		1	1									1			4	0.00
White sucker		2		1				1				2			2	8	16	0.10
Yellow bullhead			1			1				5							7	0.10
Yellow perch																1	1	0.00
No. of Fish Sampled	755	621	390	264	1720	1315	463	395	1341	362	966	484	1638	1002	550	797	13063	
Distance Sampled (ft)	500	1100	700	700	400	600	750	910	750	1155	850	1200	1100	1400	600	1600	14315	
CPUE	1.510	0.565	0.557	0.377	4.300	2.192	0.617	0.434	1.788	0.313	1.136	0.403	1.489	0.716	0.917	0.498		
Combined CPUE	0.860		0.467		3.035		0.517		0.894		0.707		1.056		0.612		0.913	100.00

It appears that with environmentally friendly ways to pass sediment, fish below Spencer Dam survive and express resilience to conditions created by sluicing. Sediments can pose detrimental effects on aquatic ecosystems, but many of the mechanisms for toxicity are still unclear (Waters 1995). In the case of Spencer Hydro and the lower Niobrara River, it may be that the fish present in this river system are highly adapted to periodic high silt load conditions that prevail in sandbed prairie streams.

Generally, the species composition has not dramatically changed, with possible exception of decrease of river shiners from the earlier, Hesse studies. This lower reach of the Niobrara River appears to have fishery populations that have adapted to the annual perturbations caused by sluicing or short-term sediment releases.

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