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FISHES OF THE MISSOURI NATIONAL RECREATIONAL RIVER, SOUTH DAKOTA AND NEBRASKA

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ABSTRACT—Two sections of the Missouri River, one extending 94 km downstream from Gavins Point Dam, and the other extending 62 km downstream from Fort Randall Dam, are legally designated as National Recreational Rivers. An ichthyofaunal list and fish habitat data were needed for conservation planning by states and federal agencies (e.g., National Park Service). We collected fish during three summers from four macrohabitats, using five fish collection techniques, and measured fish habitat characteristics. Temperature, conductivity, and turbidity varied little, but substrate, depth, and velocity differed among macrohabitats (e.g., depth and velocity in the channel exceeded those elsewhere; sand dominated the substrate except in silt-laden tributary mouths and backwaters). We collected 21,699 fish of 53 species and combined our survey with others to compile a list of 92 species. Common recreational species included walleye (*Sander vitreum)* and catfishes (Ictaluridae). Twenty nonnative species were present. Seventy-two native species have persisted, but the pallid sturgeon (*Scaphirhynchus albus*) is endangered and a few other species (e.g., native minnows) may be in decline.

Key Words: exotic species, fish, habitat, Missouri River, Wild and Scenic Rivers Act

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Introduction

The purpose of the Wild and Scenic Rivers Act (1968) is to protect unique rivers, their immediate environments, and their fish and wildlife populations for human benefit. Under the act, rivers are classified as wild, scenic, or recreational according to the amount of access and development. Wild and scenic rivers are pristine and remote, whereas recreational rivers have esthetic characteristics but are readily accessible by road and may have some shoreline development, impoundments, or diversions. Federal agencies (e.g., National Park Service, Bureau of Land Management, U.S. Forest Service) prepare management plans to protect rivers designated under the act.

Portions of nine rivers comprising about 1,000 km have been designated as wild, scenic, or recreational in the Great Plains. Much of the central and northern Great Plains is drained by the Missouri River, where three segments have been legally designated as national rivers. Protected river reaches are the 250 km wild and scenic section in Montana, and two sections of the Missouri River on the South Dakota-Nebraska border designated as recreational, which are the subject of this study. Other rivers protected by the act in the Great Plains include portions of the Pecos River in New Mexico, the Clarks Fork of the Yellowstone (Wyoming), the Cache la Poudre (Colorado), and the Eleven Point River (Missouri).

The Missouri National Recreational River (94 km) was established in 1978 downstream from Gavins Point Dam, which created Lewis and Clark Lake, to the beginning of the channelized section near Ponca, Nebraska (the "Gavins" section). In 1991 a 62 km section upstream from Lewis and Clark Lake to Fort Randall Dam was added to the recreational river program (the "Randall" section). These river sections are scenic, have historic physical characteristics, and provide fishing, hunting, and recreation values that are increasing yearly. Our study comes at a turning point in the management of the Missouri River and other rivers of the United States, because of the shift in emphasis from the *development* of water resources to *better management* of water resources (WCD 2000; CMRES 2002). The shift to reallocation, conservation, and ecosystem restoration has led to contentious legal and political involvement in river management. Implementing a management plan for these recreational river sections is difficult because of the multiple uses of the river and reservoir system. Consensus-based plans for conservation are sometimes inadequate for river restoration and fish conservation (Brower et al. 2001).

State agencies recognize tourism benefits of these river sections and monitor the recreational fishery. The National Park Service manages both sections, sharing management with the US Army Corps of Engineers in the Gavins section. River conditions depend on specifications outlined in the Master Water Control Manual, but changes in the manual have been debated since 1989 without resolution. A National Research Council committee was recently asked to review the situation and recommend policies and institutional arrangements that could improve scientific knowledge of the system and promote adaptive management to meet contemporary and future needs in the basin (Berry 2003).

The general management plans for the recreational river sections call for documenting and monitoring the fish community (NPS 1998). The purpose of our study was to (1) synthesize our new data with unpublished information into an ichthyofaunal list for the recreational river sections, and (2) report aquatic habitat conditions present in dominant macrohabitats. Our study was part of a larger study of the main stem of the Missouri River from Montana to St. Louis, MO, exclusive of reservoirs (Berry and Young 2001; Pegg and Pierce 2002).

Study Site

The recreational river sections form part of the boundary between Nebraska and South Dakota (Fig. 1). These river sections appear to be relatively natural and somewhat similar to conditions that Lewis and Clark described, including in some reaches the shallow waters, shifting sand bars, and snags that plagued early boat traffic (Burroughs 1961). River width averages about 600 m and varies from 200 m to 1.6 km; depth can be 6 m in pools, but much of the river is shallow (<1 m). Annual discharge after the dams were closed averaged 10,000 m^3sec^{-1} at Sioux City, IA, whereas discharges during our study were 1.4, 1.9, and 1.1 times normal in 1996, 1997, and 1998, respectively (Galat et al. 2001). Common aquatic macrohabitats are: main channel and border, secondary channels, backwaters, pools downstream from sandbars, and tributary confluences. Sandbars and islands are common. The floodplain is fairly level, except for areas of steep, tree-covered bluffs along some river reaches. Riverbanks vary from relatively flat, sandy beach areas to 5 m vertical faces where active erosion is taking place. Most of the 32 tributaries are intermittent or have small annual mean discharges (<2.5 m^3sec^{-1}, e.g., Choteau and Ponca creeks), but the Niobrara River (48 m^3sec^{-1}) in the Randall section, and the Vermillion (11 m^3sec^{-1}) and James (17 m^3sec^{-1}) rivers in the Gavins section, are substantial.

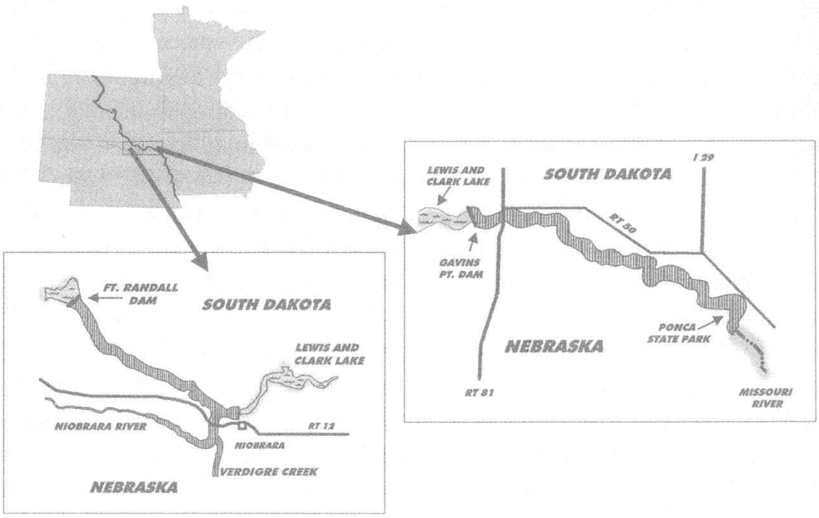

Figure 1. Map showing two reaches (hash-marked area) of the National Recreational River system on the Nebraska-South Dakota border.

Operation of the dams has caused changes in aquatic habitat (Schmulbach et al. 1981; Galat and Lipkin 2000). For example, turbidity and temperature have decreased, the flood pulse has been disturbed (e.g., flow maxima decreased), channel incision has increased (thus dewatering off-channel macrohabitats), bottom substrate size has increased because of scouring (Holly and Karim 1986), and aggradation in the upper end of Lewis and Clark Lake has created delta and marsh habitats. Habitat change and fish stocking caused shifts in the kinds and numbers of plankton, macro-invertebrates, and fishes after dams were closed (Morris et al. 1968; Walburg et al. 1971), and perturbations continue (Hesse and Sheets 1993; CMRES 2002). Habitat degradation and commercial fishing had negative effects on recreational catfish populations (Mestl 1999a).

Historic surveys were made by Lewis and Clark and by expeditions and railroad surveys in the late 1800s, but the historic information on fishes is scanty (e.g., Meek 1894; Evermann and Cox 1896; Churchill and Over 1938; Johnson 1942; Moring 1996). After the dams were closed in the early 1950s, studies were done to investigate changing conditions and biota (McComish 1967; Nelson 1968; Walburg et al. 1971; Schmulbach et al. 1975; Kallemeyn and Novotny 1977). Bailey and Allum (1962) used seines in shallow areas to

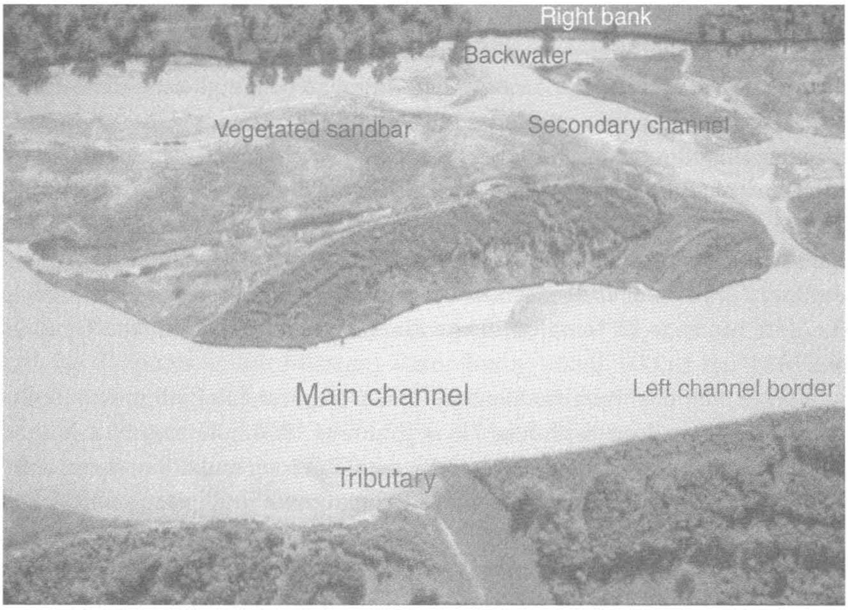

Figure 2. Aerial view of a portion of the Missouri River showing various aquatic macrohabitats sampled for fishes, 1996-1998. Note tributary (bottom-center), main channel (center), and connected and unconnected secondary channels in the sand bar complex (top).

collect 30 fish species between 1952 and 1956 at sites now in the recreational river sections. Since the 1980s a substantial recreational fishery (about $5 million annually) has developed for walleye, freshwater drum, catfish, and other species. While monitoring this fishery, state agency biologists have annually recorded from 40 to 50 species (e.g., Wickstrom 1995, 1997, 2003; Mestl 1999b, 2000). A fish database has been compiled by the Nebraska Game and Parks Commission (Mestl 2003). Other recent studies have been on fish sampling methods (Van Zee et al. 1996; Jordan 2000) and fish ecology (Hesse et al. 1979; Van Zee 1996).

Methods

Our study was done in 1996, 1997, and 1998 during 12 to 13 weeks in late summer when juveniles of most fishes could be routinely captured and identified. We sampled with a variety of active and passive equipment in four macrohabitats (Fig. 2): channel bends (channel crossovers, inside bends, outside bends), tributary mouths (TRM), secondary channels connected to the main stem (SCC), and secondary channels not connected to the main stem (SCN), which we term "backwaters." We further divided these macrohabitats into smaller units termed mesohabitats (e.g., sand bars, channel borders, deep pools or steep shorelines of inside bends, large and small tributary mouths, deep and shallow secondary channels). The number of each macrohabitat in each section was determined from maps and site visits, and then macrohabitats were randomly selected each year for sampling. We sampled 30 bends, 45 SCCs, 15 SCNs, and 25 TRMs over the three years of the study. The number of macrohabitats sampled was similar in each reach (i.e., 15 bends were sampled in the Gavins reach and 15 in the Randall reach).

Five methods were used to collect fish. Experimental gill nets were 30 m long by 1.8 m deep, with four 7.6 m panels of 19, 38, 51, and 76 mm (bar measure) mesh netting. Trammel nets were 23 m long and 1.8 m deep, with a 25 mm (bar measure) inner mesh and 203 mm outer mesh. Bag seines were 10.7 m long and 1.8 m deep, with 5 mm (bar measure) mesh. The benthic trawl was hung on a rigid frame with skis. The trawl net was 2 m wide, 0.5 m deep, and 5.5 m long, with 3.2 mm inner mesh. Electrofishing was done with a 5,000 watt generator using pulsed DC current and two persons netting with 5 mm mesh dip nets. A minimum of two fish collection methods was used in each mesohabitat. The exceptions were shallow habitats, where only a seine was used.

We measured habitat conditions at each fish sampling location following standard procedures (Sappington et al. 1998). Habitat measurements were made at the midpoint of a deployed gill net or seine, and at the midpoint of the area covered by a drifting trammel net, shocking boat, or benthic trawl. Depth was measured with sonar. Water velocity was measured with a flow meter (Marsh McBirney) at 0.2 and 0.8 times depth where depths were >1.2 m and at 0.6 times depth otherwise. We determined substrate by estimating the percentage of cobble, gravel, sand, and silt in dredge contents. Turbidity was measured with a turbidimeter (Hach, Model 2100P); temperature was also measured with a meter (YSI, Model 30).

Results and Discussion

We collected 21,699 fish of 53 species: 5,209 fish of 45 species in the Randall section and 16,490 fish of 53 species in the Gavins section. Higher species richness in the Gavins section might be expected because it is open to fish immigration from downstream. All species found in the Randall section were found in the Gavins section (except black bullhead). About 68% of the catch in the Gavins section was composed of emerald shiners, gizzard shad, and quillback carpsuckers. These species and other typical large river species (e.g., bigmouth buffalo, blue sucker, flathead catfish, freshwater drum) were much more common in the Gavins section than in the Randall section.

We did not find all reported species even though we attempted to maximize our species list by sampling with a variety of methods in a variety of habitats over three years. Combined data from our study, past studies, agency surveys, and angler catches produced a list of 92 species (Tables 1 and 2). Throughout the Missouri River basin, about 100 of the 156 fish species are considered main-channel inhabitants (Hesse 1996), so the recreational river sections hold about 90% of the fish species richness of the Missouri River main stem and about 57% of the species in the basin, assuming those documented in earlier studies are still present.

Agency and institutional surveys listed 38 species that we did not collect, and we added no new species. Agency surveys recorded more species than we did because they have been done annually since 1970 (Nebraska) and 1991 (South Dakota). Anglers did not add any species to the list, but they caught 42 species of fish (mostly walleye, freshwater drum, channel catfish) and two hybrids: tiger musky (muskellunge crossed with northern pike) and sunfish hybrids (e.g., green sunfish crossed with bluegill). Saugeye (walleye crossed with sauger) are probably caught also (Van Zee 1996). Anglers from 29 states fish in the recreational river sections, and about 69% fished there repeatedly (Mestl et al. 2001).

Exotic and Introduced Species

We found 20 exotic or introduced species comprising 22% of the fish fauna (Table 2), about the same percentage as for the entire main stem Missouri River (Berry et al. 2003). Exotic species are not endemic to North America, whereas introduced species are North American but are outside of their native range. We found more introduced than imperiled or extirpated species, so invaders tend to increase overall species richness, as has been observed in other drainages with impoundments, large basin areas, and low native species diversity (Gido and Brown 1999).

Exotic species are from Asia (grass carp, bighead carp, and goldfish) and Europe (common carp and brown trout). Goldfish, common carp, and brown trout have expanded since their introduction more than 100 years ago,

TABLE 1

NATIVE FISHES RECORDED IN SURVEYS IN THE MISSOURI RIVER SECTIONS ON THE SOUTH DAKOTA-NEBRASKA BORDER AND NUMBER FOUND DURING THIS STUDY, 1996-98

Family and Scientific name	Common Name	Fort Randall	Gavins Point	References[a]
Petromyzontidae				
Ichthyomyzon unicuspis	Silver lampery	0	0	2,5
Acipenseridae				
Acipenser fulvescens	Lake sturgeon	0	0	1,3,5
Scaphirhynchus albus	Pallid sturgeon	0	0	1,2,3,4,5,6,7
Scaphirhynchus platoryhnchus	Shovelnose sturgeon	17	62	1,2,3,4,5,6,7,8
Polyodontidae				
Polyodon spathula	Paddlefish	1	2	1,2,3,4,5,6,7,8
Lepisosteidae				
Lepisosteus oculatus	Spotted gar	0	0	1
Lepisosteus osseus	Longnose gar	0	38	1,2,3,4,5,6,7,8
Lepisosteus platostomus	Shortnose gar	9	44	1,2,3,4,5,6,7,8
Hiodontidae				
Hiodon alosoides	Goldeye	56	188	1,2,3,4,5,6,7,8
Anguillidae				
Anguilla rostrata	American eel	0	0	1,2,3,5,7
Clupeidae				
Alosa chrysochloris	Skipjack herring	0	0	1,2,3,4,5,6,7,8
Dorosoma cepedianum	Gizzard shad	174	4360	1,2,3,4,5,6,7,8
Esocidae				
Esox lucius	Northern pike	17	17	1,2,3,4,5,6,7,8
Esox americanus[b]	Grass pickerel	0	1	1,3,4,5
Cyprinidae				
Campostoma anomalum	Central stoneroller	0	0	1,2,3,4,5
Cyprinella lutrensis	Red shiner	55	254	1,2,3,4,6,7
Cyprinella spiloptera	Spotfin shiner	718	768	1,4
Hybognathus argyritis	Western silvery minnow	0	1	1,4,7
Hybognathus hankinsoni	Brassy minnow	2	82	1,2,3,4,5
Hybognathus nuchalis	Mississippi silvery minnow	0	0	2,3,5
Hybognathus placitus	Plains minnow	0	0	1,2,3,5
Luxilus cornutus	Common shiner	0	0	3,4
Macrhybopsis aestivalis	Speckled chub	0	0	1,3,5
Macrhybopsis gelida	Sturgeon chub	0	0	1,2,3,5
Macrhybopsis meeki	Sicklefin chub	0	1	1,2,3,5
Macrhybopsis storeriana	Silver chub	8	1	1,2,3,4,5,6,7
Notemigonus crysoleucas	Golden shiner	1	55	2,3,4,5
Notropis atherinoides	Emerald shiner	1137	4965	1,2,3,4,5,6,7
Notropis blennius	River shiner	23	200	1,2,3,5,6
Notropis buchanani	Ghost shiner	0	0	1,5
Notropis dorsalis	Bigmouth shiner	0	68	1,2,3,5,7
Notropis stramineus	Sand shiner	12	383	1,3,4,5,6,7
Notropis shumardi	Silverband shiner	0	0	5
Notropis volucellus	Mimic shiner	1	4	5
Phenacobius mirabilis	Suckermouth minnow	0	0	1,2,3,4,5
Phoxinus eos	Northern redbelly dace	0	0	1,3,5
Pimephales notatus	Bluntnose minnow	3	1	1,2,3,4,5

TABLE 1 continued

Family and Scientific name	Common Name	Fort Randall	Gavins Point	References[a]
Pimephales promelas	Fathead minnow	8	8	1,2,3,4,5,6,7
Platygobio gracilis	Flathead chub	10	7	1,3
Rhinichthys atratulus	Blacknose dace	0	0	1,2,5
Rhinichthys cataractae	Longnose dace	0	0	1,2,5
Semotilus atromaculatus	Creek chub	0	0	1,2,3,4,5
Catostomidae				
Carpiodes carpio	River carpsucker	212	516	1,2,3,4,5,6,7,8
Carpiodes cyprinus	Quillback	42	1875	1,2,3,4,5,7
Carpiodes velifer	Highfin carpsucker	0	1	3,5
Catostomus commersoni	White sucker	6	2	1,2,3,4,5,7
Cycleptus elongatus	Blue sucker	0	36	1,3,5,6,7,8
Ictiobus bubalus	Smallmouth buffalo	17	97	1,2,3,4,5,6,7,8
Ictiobus cyprinellus	Bigmouth buffalo	6	23	1,2,3,4,5,6,7,8
Ictiobus niger	Black buffalo	0	0	3,5
Moxostoma erythrurum	Golden redhorse	0	0	1,2,3,5
Moxostoma macrolepidotum	Shorthead redhorse	22	237	1,2,3,4,5,6,7,8
Ictaluridae				
Ameiurus melas	Black bullhead	5	0	1,2,3,4,5,6,7,8
Ameiurus natalis	Yellow bullhead	0	0	1,3,5,6,8
Ictalurus furcatus	Blue catfish	0	0	1,2,3,4,5,6,8
Ictalurus punctatus	Channel catfish	403	257	1,2,3,4,5,6,7,8
Noturus flavus	Stonecat	4	4	1,2,3,5
Noturus gyrinus	Tadpole madtom	0	0	1,2,3,5
Pylodictis olivaris	Flathead catfish	3	133	1,2,3,4,5,6,7,8
Gadidae				
Lota lota	Burbot	1	1	1,2,3,5,6,7,8
Cyprinodontidae				
Fundulus sciadicus	Plains topminnow	0	0	1,2,3,5
Gasterosteidae				
Culaea inconstans	Stickleback	0	0	1,2,3,5
Percichthydidae				
Morone chrysops	White bass	40	197	1,2,3,4,5,6,7,8
Centrarchidae				
Ambloplites rupestris	Rock bass	13	9	1,2,3,4,5,7,8
Lepomis cyanellus	Green sunfish	11	16	1,2,3,4,5,7,8
Lepomis humilis	Orangespotted sunfish	0	4	1,2,3,4,5,7,8
Percidae				
Etheostoma exile	Iowa darter	0	0	1,2,3,5,7
Etheostoma nigrum	Johnny darter	80	22	1,2,3,4,5,7
Perca flavescens	Yellow perch	492	140	1,2,3,4,5,6,7,8
Sander canadense	Sauger[c]	21	79	1,2,3,4,5,6,7,8
Sander vitreum	Walleye[c]	76	161	1,2,3,4,5,6,7,8
Sciaenidae				
Aplodinotus grunniens	Freshwater drum	47	374	1,2,3,4,5,6,7,8

[a] 1 = Mestl (2003), 2 = Bailey and Allum (1962), 3 = Morris et al. (1974), 4 = Wickstrom (1995, 1997, 2003), 5 = Hesse et al. (1989), 6 = Schmulbach et al. (1975), 7 = Kallemeyn and Novotny (1977), 8 = Mestl et al. (2001).

[b] *Esox americanus vermiculatus* is the subspecies for grass pickerel that is native to the Mississippi River basin and the Sand Hills of Nebraska (Crossman 1978).

[c] Hybrids reported as saugeye (walleye x sauger).

TABLE 2

NONNATIVE FISHES RECORDED IN SURVEYS IN THE MISSOURI RIVER SECTIONS ON THE SOUTH DAKOTA-NEBRASKA BORDER AND NUMBER FOUND DURING THIS STUDY, 1996-98

Family and Scientific name	Common Name	Fort Randall	Gavins Point	References[a]
Clupeidae				
Alosa pseudoharengus	Alewife	0	0	1,3,5
Cyprinidae				
Carassius auratus	Goldfish	0	0	1,2,3,5
Ctenopharyngodon idella	Grass carp	0	6	1,4,5,8
Cyprinus carpio	Common carp	234	413	1,2,3,4,5,6,7,8
Hypophthalmichthys nobilis	Bighead carp	0	0	1,4,8
Notropis hudsonius	Spottail shiner	3	13	1,2,4,5
Esocidae				
Esox masquinongy	Muskellunge[b]	0	0	1,3,4,5
Osmeridae				
Osmerus mordax	Rainbow smelt	1	1	1,4,5
Salmonidae				
Oncorhynchus mykiss	Rainbow trout	0	0	1,3,4,5,8
Salmo trutta	Brown trout	0	0	1,2,3,4,5,8
Percichthyidae				
Morone americana	White perch	0	0	4,5
Centrarchidae				
Archoplites interruptus	Sacramento perch	0	0	1,3,5
Lepomis gibbosus	Pumpkinseed	0	0	1,2,3,5
Lepomis microlophus	Redear sunfish	0	0	3,4
Lepomis macrochirus	Bluegill[b]	103	39	1,2,3,4,5,6,7,8
Micropterus punctatus	Spotted bass	0	0	1,3,5,8
Micropterus dolomieu	Smallmouth bass	147	230	1,2,3,4,5,7,8
Micropterus salmoides	Largemouth bass	164	46	1,3,3,4,5,6,7,8
Pomoxis annularis	White crappie	925	38	1,2,3,4,5,6,7,8
Pomoxis nigromaculatus	Black crappie	17	10	1,2,3,4,5,6,7,8

[a] 1 = Mestl (2003), 2 = Bailey and Allum (1962), 3 = Morris et al. (1974), 4 = Wickstrom (1995, 1997, 2003), 5 = Hesse et al. (1989), 6 = Schmulbach et al. (1975), 7 = Kallemeyn and Novotny (1977), 8 = Mestl et al. (2001).
[b] Hybrids reported as bluegill x green sunfish, and muskellunge x northern pike (tiger musky).

whereas grass carp and bighead carp are recent imports (1963 and 1973, respectively) that grow to a large size (31 kg), have spread rapidly, and are reproducing in the Missouri River (Brown and Coon 1991). The grass carp may impact aquatic macrophytes that are important fish habitat (Stanley et al. 1978), and bighead carp may compete with native planktivores such as the bigmouth buffalo and paddlefish (Jennings 1988). Gavins Point Dam has stopped the invasion of these species into the upper Missouri River basin.

Introduced species include game fish and prey species stocked into basin lakes and reservoirs during two periods. In the late 1800s species such as the largemouth bass, white and black crappie, pumpkinseed sunfish, and bluegill were stocked into lakes and streams in the vicinity of the recreational river sections, thus making native range determination difficult (Bailey and Allum 1962; Morris et al. 1974; Harlan and Speaker 1987). In the 1950s impoundment of the Missouri River created new habitats that fishery managers exploited to provide recreational fishing. Some stocked species, for example, striped bass (*Morone saxatalis*), coho salmon (*Oncorhynchus kisutch*), and lake trout (*Salvalinus namaycush*), apparently did not survive, but others did. Rainbow and brown trout, chinook salmon, muskellunge, and smallmouth bass survived in the new cold and cool water habitats of deep reservoirs and dam tailraces. Prey species (e.g., rainbow smelt, lake herring, spottail shiner) were successfully stocked to support the new predatory game fish (Freiburger 1992; Sewell 1993). Sacramento perch and white perch were introduced into a few Nebraska lakes in the 1960s (Morris et al. 1974) and have since expanded their distribution into the Missouri River. Introduced predators have been associated with the decline of native turbid-river cyprinids such as the flathead chub, sturgeon chub, plains minnow, and western silvery minnow (Quist et al. in press).

Native Species

Seventy-two native species have been found in this and past studies in the recreational river sections. Twenty-nine of these species are relatively abundant (>20 specimens, Table 1) and have been regularly caught in past surveys or by anglers. The group of common native species includes eight cyprinids, six catostomids, two ictalurids, four percids, and nine other species representing the Hiodontidae, Esocidae, Percichthyidae, Centrarchidae, Clupidae, Acipenseridae, Lepisosteidae, and Sciaenidae families. Dominant species were (in declining order) emerald shiner, gizzard shad, quillback, spotfin shiner, river carpsucker, channel catfish, yellow perch, freshwater drum, sand shiner, red shiner, shorthead redhorse sucker, goldeye, river shiner, white bass, walleye, flathead catfish, smallmouth buffalo, johnny darter, and sauger. The remaining species and certain selected species mentioned above have been grouped for discussion as: (1) rare species, (2) ancestral species, and (3) incidental species on the edge of their range but common elsewhere.

Rare Species: Though historical records are scanty, no Missouri River fish species was considered extirpated from the middle Missouri River in the mid-1900s (Bailey and Allum 1962; Morris et al. 1974), and all species seem to have persisted since then. The pallid sturgeon is the only federally listed endangered fish in the Missouri River. Seventeen pallid sturgeon were caught in Lewis and Clark Lake just after Gavins Point Dam closed in 1995 (Walburg 1964), and one was found in the Randall section in 1976 (Kallemeyn and Novotny 1977). Pallid sturgeon were not caught in our study, but the species is sometimes reported in agency surveys. Young pallid sturgeons, some tagged with sonic tags, were stocked into the recreational river sections for the first time in 2002 and are being monitored to learn more about their survival and ecology.

The sicklefin chub and the sturgeon chub are listed by states as rare and have been suggested for federal listing. Bailey and Allum (1962) found these species somewhat common at sites now within the recreational river sections. We found no sturgeon chubs and one sicklefin chub even though we used the same collection method, a benthic trawl in the main channel, that was recently used to capture several hundred sicklefin chubs and several thousand sturgeon chubs in other sections of the Missouri River (Grady and Milligan 1998; Dieterman 2000; Welker 2000). Hesse et al. (1993) previously warned that these and other species of river chubs were declining. Sturgeon chubs are somewhat common in some western tributaries to the Missouri River in South Dakota (Hampton and Berry 1997; Fryda 2001), but no sicklefin chubs have been recorded in tributaries to the recreational river sections.

Species of concern are species of river chubs, minnows, and sport fish for which Hesse et al. (1993) presented evidence of decline. Of this group, the sauger, flathead chub, and silver chub may have lower populations than in the past, but they are still common. Sauger declined in abundance after the dams were closed in the 1950s (Walburg 1964; Hesse et al. 1993), but we collected 100 specimens, anglers catch several thousand yearly (Mestl et al. 2001), and natural reproduction is occurring (Van Zee 1996). Flathead chubs may be declining in the lower Missouri River (Pfleiger and Grace 1987), and our low catch confirms that they may be declining in the middle Missouri River as well. But flathead chubs are still common in western tributaries to the Missouri River in South Dakota (Hampton and Berry 1997; Loomis et al. 1999; Harland 2003) and in the upper Missouri Basin (Welker 2000). Silver chubs may be difficult to capture because of their rarity and patchy distribution. Hesse et al. (1993) collected seven fish over seven years, whereas we collected nine silver chubs, but under unusual circumstances. All nine fish were collected in one day at a tributary mouth (Choteau Creek). Some 384 silver chubs were collected during a concurrent study in the Iowa and Missouri portions of the Missouri River main stem (Berry and Young 2001). We did not collect speckled chubs, but they are occasionally collected by state agencies in the recreational river section. This species is expanding in relative abundance in the lower Missouri River (Pfleiger and Grace 1987).

The western silvery minnow, Mississippi (central) silvery minnow, plains minnow, and brassy minnow are species of *Hybognathus* that are difficult to distinguish during field surveys. We found 84 brassy minnows that we identified by its brassy dorsal surface above a dark lateral stripe. The western silvery and plains minnows are so similar in appearance that necropsy is required to examine the shape of the bassioccipital bone, and it is not always accurate (Loomis 1997). This identity problem biases data on the relative abundance and temporal change in their populations. Cross and Moss (1987) reported a ratio of plains to western silvery minnow of 10:1 in the lower Missouri River main stem. Hesse et al. (1993) combined the western silvery minnow and plains minnow when reporting that their relative abundance among small fishes declined from 28% to 1.6% over 20 years in the channelized Missouri River in Nebraska. Hesse et al. (1993) found 21 individuals (combined western silvery and plains minnows) in the recreational river section where their populations declined after impoundment (Walburg 1964). We found one western silvery minnow and did not expect to find the Mississippi silvery minnow because it is on the edge of its range in the Missouri River.

Ancestral Species: The paddlefish is an ancestral species that is a symbol of the native fishes of the Missouri River because of its large size, unusual rostrum or "paddle," and the trophy fishery it provides. The paddlefish is one of the largest freshwater fishes (up to 2 m long and weighing 45 kg) and is the only species of Polyodontidae found in North America (Dillard et al. 1986). Adult paddlefish trapped between Missouri River dams did not spawn, and populations began to decline because of overfishing (Unkenholz 1986). Today, the recreational harvest in the Gavins section is limited to about 3,000 fish during a 30-day season. In the Randall section, migrating adults are captured for spawning, and fingerlings are reared in captivity for stocking back into the Missouri River system.

The sturgeon family (Acipenseridae) is represented by the pallid, shovelnose, and lake sturgeon. The shovelnose sturgeon is commonly found, whereas the lake sturgeon has always been uncommon in the Missouri River (Morris et al. 1974), but is more common in the Mississippi River, Hudson Bay, and Great Lakes basins (Hubbs and Lagler 1967; Lee et al. 1980). Shovelnose sturgeons are similar to the endangered pallid sturgeons but are smaller (maximum length about 1 m and weight about 3.6 kg). Shovelnose sturgeon growth in the Missouri River varies by region. For example, 10-year-old fish in the Yellowstone River average 74.5 cm long, whereas those in the recreational river sections average only about 50.0 cm long. Berry et al. (2003) captured five adult shovelnose sturgeons that were 50.5 to 55.8 cm in length and had been tagged in the Gavins section 13 years earlier. These individuals had grown an average of 1.2 cm in length; two had gained weight and three had lost weight. The slow growth may be attributed to altered thermal regimes, food web productivity, or habitat change, which are reasons suggested for the decline of native minnows (Hesse et al. 1993).

The gar family (Lepisosteidae) includes seven species that are exclusively North American, of which three have been recorded in the recreational river sections. Gars are ancestral fishes that retain a cartilaginous skeleton and have dermal armor in the form of bony plates and ganoid scales. Gars are able to augment respiration by using the gas bladder as a "lung," are tolerant of degraded conditions, and are usually associated with backwater habitats. Shortnose gars and longnose gars were somewhat common in our study, more so in the Gavins section than the Randall section. The spotted gar is common in the lower Mississippi River and Great Lakes, usually in clear lacustrine habitats (Hubbs and Lagler 1967; Lee et al. 1980), but is rarely found in the Missouri River (one specimen was found by Berry et al. 2003).

Both the silver lamprey and the chestnut lamprey (*Ichthyomyzon castaneus*) have been recorded in the Missouri River, but their presence in samples is rare. The silver lamprey has been recently documented (Bailey and Allum 1962; Harlan and Speaker 1987) whereas the chestnut lamprey has not, and the silver lamprey is more likely in the middle Missouri River than the chestnut lamprey (Bailey 1959). Lampreys are usually found in the upper Mississippi River and Great Lakes basin where stable gravel substrates are more common than in the Missouri River.

Incidental Native Species: Incidental species are species that occasionally appear in the recreational river sections, but are common elsewhere. Most were cyprinids that might be considered strays because they are usually associated with tributaries rather than large rivers (e.g., blacknose dace, bluntnose minnow, central stoneroller, common shiner, creek chub, longnose dace, northern redbelly dace, stonecat, suckermouth minnow). Also occasionally caught are species usually associated with lakes or ponds (e.g., orangespotted sunfish, yellow and black bullhead) or tributaries and sluggish streams (e.g., plains topminnow, Iowa darter, tadpole madtom). Reduced turbidity after dam construction has coincided with the increased abundance of native sight feeders such as skipjack herring, walleye, white bass, rock bass, and grass pickerel (Grossman 1978; Hesse et al. 1982; Pfleiger 1997).

Other incidental species are characteristic inhabitants of large rivers. The American eel is unique because it is the only catadromous species in these river sections, but it is rarely seen. The burbot is the only freshwater codfish (Gadidae) and is unusual because of its snakelike appearance and long median fins that appear to connect to the tail fin. It is a voracious predator, may exceed 9 kg, and is usually found in deep lakes but may be found in large rivers, where its body shape is more slender than for lake populations (Fisher et al. 1996). Several suckers (Catostomidae), such as the highfin carpsucker, black buffalo, and golden redhorse, are more common in the lower Missouri River basin than in the recreational river sections. The highfin carpsucker is often confused with the more abundant quillback and river carpsucker, making its records suspect (Cleary 1956). The silverband shiner has persisted in low numbers, having been first recorded near Sioux City (Meek 1892), and later at the mouth of the Vermillion River (Underhill 1959), in Lewis and Clark Lake (Harlan and Speaker 1987), and in the Nebraska segments, where it was reported as silverstriped shiner (*Notropis stilbius*) (Morris et al. 1974). The mimic shiner is usually found in tributaries (Pfleiger 1997) but may be moving into the main stem, as 100 specimens were recently collected by others in the middle and lower main stem (Berry and Young 2001).

Aquatic Habitat

In general, water quality and substrate varied little among mesohabitats and between sections, whereas depth and velocity varied greatly. Table 3 provides an overview of the many measurements made in macro- and mesohabitats, whereas Tables 4 and 5 provide details. Water temperatures reflected the summer sampling schedule and the warm water portions of the Missouri River downstream from the dam tailraces. In bends and connected secondary channels, water temperatures ranged from 22.2° to 25.2°C in both sections but averaged 1°C colder in the Randall section than in the Gavins

TABLE 3

RANGE OF AVERAGE CONDITIONS IN BENDS, SIDE CHANNELS, BACKWATERS, AND TRIBUTARY MOUTHS WHERE FISH WERE COLLECTED IN THE MISSOURI RIVER SECTIONS, NEBRASKA-SOUTH DAKOTA, 1996-98

Habitat characteristic	Range of means	Comment
Temperature (C)	22.6-25.2	Sampling during July and August, Randall colder than Gavins section
Turbidity (NTU)	4.3-44.3	Lower in Randall than Gavins section; lower in main stem than tributaries
Conductivity (mSm^{-1})	80.2-109.3	Highest in tributaries and backwaters
Depth (m)	0.5-5.5	Deepest in main stem channels, moderate in secondary channels and tributaries, shallow in backwaters, shoreline varied with bank angle
Velocity ($msec^{-1}$)	0.-1.1	Little flow in backwaters to maximum velocity in the channel
Substrate	70%-100% sand	Sand substitute usual in the middle Missouri River, with mostly silt in backwaters and tributaries, and some gravel in channels

section (Table 4). Hypolimnetic discharges from Fort Randall Dam were about 1°C lower than the hypothetical natural temperature of the unimpounded river (Galat et al. 2001). Temperatures in the Gavins section were similar to the hypothetical natural temperature of the river.

Conductivity ranged from 80.2 to 109.3 mSm^{-1} and was similar in both the Randall and Gavins sections. Conductivity tended to be higher in tributaries and backwaters, perhaps reflecting the geology of the watershed and limnological conditions in backwaters. Conductivity in this section of the river was similar to values recorded in the middle and lower Missouri River (Galat et al. 2001).

The general pattern of substrate quality was that sand dominated (70%-80%) the main-channel flowing-water habitats whereas silt dominated (90%) tributary mouths and backwaters (Tables 4 and 5). Gravel amounted to 10%-30% of the bottom sample in some bends where water currents scoured the substrate, but was less prevalent in other mesohabitats.

Turbidity ranged from 4.3 to 44.3 Nephelometric Turbidity Units (NTUs) and there were some differences among sampling sites. In flowing-

TABLE 4

MEAN (STANDARD DEVIATION) PHYSICAL AND WATER QUALITY CONDITIONS AT CHANNEL CROSSOVERS AND IN THREE MESOHABITATS OF THE MISSOURI RIVER SECTIONS DOWNSTREAM FROM FORT RANDALL (FR) AND GAVINS POINT (GP) DAMS, 1996-98

Habitat measure		Channel crossover	Outside Bend bank	Outside channel border	Inside channel border	Inside bend bank[a]		
Fishing gear	River section	Trawl and trammel	Electro-fishing	Trawl and trammel	Trawl and trammel	Seining	Electro-fishing	Gill nets
Temperature (EC)	FR	23.4 (1.1)	22.8 (1.3)	22.6 (1.9)	22.6 (1.7)	22.6 (1.7)	24.8 (1.9)	22.6
	GP	22.4 (3.2)	23.4 (3.4)	23.8 (3.5)	23.5 (3.8)	25.2 (3.9)	25.0	24.1 (2.3)
Turbidity (NTU)	FR	4.3 (2.8)	8.6 (6.3)	5.2 (1.7)	5.5 (5.5)	9.2 (5.6)	6.6 (1.1)	4.8
	GP	24.8 (6.1)	27.1 (10.4)	25.4 (7.3)	25.3 (7.5)	28.9 (6.6)	27.0	25.2 (8.4)
Conductivity (mSm^{-1})	FR	86.9 (7.3)	84.1 (5.0)	87.4 (8.6)	86.4 (7.3)	80.2 (1.8)	82.1 (9.0)	80.7
	GP	83.7 (10.0)	82.0 (6.2)	85.8 (11.1)	81.2 (7.0)	83.0 (9.4)	80.3	81.0 (5.5)
Water depth (m)	FR	4.3 (1.4)	2.3 (1.3)	4.7 (1.1)	2.9 (1.1)	0.5 (0.2)	1.9 (0.2)	2.7
	GP	3.4 (1.1)	2.8 (1.9)	5.5 (1.4)	3.2 (0.9)	0.5 (0.2)	1.1	2.6 (1.1)
Water velocity ($msec^{-1}$)	FR	0.8 (0.2)	0.4 (0.2)	0.8 (0.1)	0.7 (0.1)	0.0	0.4 (0.1)	0.0
	GP	1.0 (0.2)	0.7 (0.3)	1.1 (0.3)	1.0 (0.3)	0.2 (0.1)	0.3	0.4 (0.1)
Substrate[b]	FR	S 0.9	S 0.2	S 0.8	S 0.8	S 0.7	S 0.7	S 1.0
		SL 0.1	SL 0.5	SL 0.2	SL 0.2	SL 0.3	SL 0.2	SL 0.0
	GP	S 0.8	S 0.6	S 0.7	S 0.8	S 0.9	S 0.9	S 0.7
		SL 0.0	SL 0.1	SL 0.0	SL 0.1	SL 0.1	SL 0.1	SL 0.3

[a] Characteristics of inside bend banks, mainly depth and bank angle, varied among bends, requiring different gears.
[b] S = sand, SL = silt; where sand and silt do not add to 1.0, the remainder is a mix of larger substrates (e.g., gravel, cobble).

TABLE 5

MEAN (STANDARD DEVIATION) PHYSICAL AND WATER QUALITY CONDITIONS IN SECONDARY CHANNELS AND TRIBUTARY MOUTHS IN THE MISSOURI RIVER SECTIONS DOWNSTREAM FROM FORT RANDALL (FR) AND GAVINS POINT (GP) DAMS, 1996-98

		Side channel deep, connected		Side channel shallow	Side channel not connected		Tributaries	
Habitat measure		Channel	Bank	Channel and bank	Channel	Bank	Channel	Bank
Fishing gear	River section	Trawl and trammel	Electrofishing and seining	Seining	Gill net	Electrofishing and seining	Gill net	Electrofishing
Temperature (EC)	FR	23.6 (2.4)	24.0 (1.6)	22.2 (2.6)	24.0 (3.5)	25.2 (2.6)	22.8 (2.6)	23.9 (1.5)
	GP	24.4 (3.5)	24.7 (3.8)	23.8 (2.9)	22.5 (3.6)	23.4 (2.5)	22.0 (3.5)	23.1 (2.3)
Turbidity (NTU)	FR	6.1 (2.1)	7.3 (3.4)	8.0 (6.9)	19.6 (9.1)	23.5 (17.0)	10.9 (7.1)	13.7 (7.6)
	GP	25.2 (8.9)	29.2 (9.2)	24.5 (7.7)	20.1 (7.9)	21.9 (5.8)	39.5 (26.6)	44.3 (29.2)
Conductivity (mSm^{-1})	FR	84.5 (7.70)	86.3 (8.9)	80.1 (1.8)	98.1 (14.8)	96.9 (17.1)	92.9 (10.0)	109.3 (55.3)
	GP	86.3 (6.8)	83.3 (9.1)	77.1 (5.7)	88.2 (9.1)	86.0 (5.1)	106.3 (24.1)	108.8 (26.9)
Depth (m)	FR	2.4 (0.7)	1.4 (0.9)	0.6 (0.1)	1.2 (0.5)	1.0 (0.5)	2.1 (0.7)	1.5 (0.7)
	GP	2.5 (0.9)	1.3 (0.9)	0.5 (0.1)	1.3 (0.7)	0.7 (0.4)	3.2 (2.2)	1.9 (1.3)
Velocity ($msec^{-1}$)	FR	0.6 (0.2)	0.3 (0.2)	0.2 (0.1)	0.0	0.0	0.0	0.0
	GP	0.9 (0.2)	0.5 (0.3)	0.3 (0.1)	0.1 (0.1)	0.1 (0.1)	0.0	0.0
Substrate[a]	FR	S 0.8	S 0.6	S 0.7	S 0.1	S 0.1	S 0.0	S 0.0
		SL 0.1	SL 0.2	SL 0.3	SL 0.9	SL 0.7	SL 0.9	SL 0.9
	GP	S 0.8	S 0.8	S 0.9	S 0.3	S 0.5	S 0.1	S 0.1
		SL 0.1	SL 0.1	SL 0.1	SL 0.7	SL 0.4	SL 0.9	SL 0.9

[a]S = sand, SL = silt; where sand and silt do not add to 1.0, the remainder is a mix of larger substrates (e.g., gravel, cobble).

water habitat of the Randall section, turbidity was usually <10 NTUs, whereas turbidity in like areas of the Gavins section ranged from 24 to 29 NTUs (Table 4). Turbidity in the Randall section was the lowest recorded on the main stem and was similar to that downstream from Lake Sakakawea (North Dakota), probably reflecting the series of reservoirs upstream—Lakes Oahe, Francis Case, Sharpe, and Lewis and Clark—that removed suspended sediment (Galat et al. 2001). Tributaries usually had higher turbidity values than the main stem (Table 5), so the inputs of turbid water from the Vermillion and James rivers probably explain the higher turbidity values in the Gavins section than in the Randall section. In backwaters of the Randall section, turbidity was three times higher than in flowing water, whereas turbidity in backwaters of the Gavins section was similar to that in the main stem (Tables 4 and 5).

Depth and velocity differed among mesohabitats. The main channels at crossovers and bends had depths of 2.9-5.5 m and velocities of 0.7-1.1 $msec^{-1}$ (Table 4). Deep secondary channels had less water depth (about 2.5 m deep) and lower water velocities (0.6-0.9 $msec^{-1}$) than did the main channel. Water in shallow secondary channels was shallower (0.5-0.6 m) and had less velocity (0.2-0.3 $msec^{-1}$) than water in deep secondary channels (Table 5). Depth in nonconnected secondary channels averaged 1 m and velocity was essentially zero.

The habitat data have several applications, which is why they are traditional stream habitat measurements (Bain and Stevenson 1999). The measurements can provide an index to trends in river conditions among study sections and macrohabitats that might explain differences in fish community or population attributes. Differences among tributaries in conductivity, turbidity, and flow volume variously influence the main stem. Our data also allow future surveyors to conduct fishery surveys under similar conditions and to determine temporal trends in habitat conditions. Physical habitat data can also be used in concert with biological data to assess habitat improvement activities and habitat suitability for fish.

Conclusion

The quality and quantity of data on fish in the recreational river sections is substantial and provides valuable information to the public and agencies focusing attention on the fishery resources. We presented a list of 72 native species and 20 nonnative species that might be found in the recreational river sections. The sparse historical record of fishes in these sections allows presumptive estimates of temporal trends in native species richness (Strayer 1999). All species generally associated with the main stem that were listed by earlier surveys have persisted, but the populations of some may be declining. Ecological persistence is the continued existence of species over time and stability is the constancy of numbers of individuals over time (Connell and Sousa 1983). We conclude, as have others, that species of concern in these sections of the Missouri River are the sturgeon chub, sicklefin chub, flathead chub, silver chub, speckled chub, plains minnow, western silvery minnow, and pallid sturgeon. The harvest of paddlefish is routinely monitored, and artificial propagation and successful stocking seem to have assuaged earlier fears that it was a threatened resource (Dillard et al. 1986). We found a relatively high proportion (22%) of introduced and exotic species. Some are important recreational species, but in general this group may alter the native fish community. Species lists are useful because the presence of a species, usually a recreational or rare species, is sometimes the only information that prompts management actions or garners public attention. Additionally, our list may help river managers with resource stewardship decisions and public information and education programs.

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