State of Nebraska

Game and Parks Commission

Fisheries Division

Federal Aid in Fish Restoration

Dingell-Johnson Project

F-75-R-8

Performance Report

Study I

1 March 1990 through 28 February 1991

Table of Contents

1. Project and study objectives.

2. Summary of 1990 fish collections.

3. Appendix A. The status of paddlefish and the snag fishery in the Nebraska portion of the Missouri River. Page 24.

4. Appendix B. Walleye in the unchannelized Missouri River in Nebraska. Page 47.

5. Appendix C. The effects of hydropower peaking operations at Fort Randall Dam, Missouri River, on Aufwuch macroinvertebrates downriver. Page 58.

6. Appendix D. Catfish management in the Missouri River with special emphasis on flathead catfish. Page 98.

7. Appendix E. Compendium of fisheries data from the Missouri River, Nebraska. Page 112.

Key Words: Fishes, freshwater, electrofishing, netting, rivers, channelization, water level management, tailwaters, life history data, catfish, sauger, walleye, paddlefish, cyprinids.

Performance Report

State: Nebraska Project Number: F-75-R-8

Project Type: Research

Study Title and Objectives:

Study I. Missouri River Ecology

Monitor changes in fish populations living in unchannelized and channelized sections of the Missouri River; acquire other pertinent data annually from the biological and physical system (such as primary and secondary productivity estimates, feeding behavior of organisms at various trophic levels, chemical and physical limnology, fish yield, etc.), which, when understood, will clarify the factors which effect these changes.

1. Job objective I-1.

Monitor changes in fish populations living in unchannelized and channelized sections of the Missouri River; acquire other pertinent data annually from the biological and physical system (such as primary and secondary productivity estimates, feeding behavior of organisms at various trophic levels, chemical and physical limnology, fish yield, etc.), which, when understood, will clarify the factors which effect these changes.

a. Activity.

The 1990 segment was completed as scheduled.

b. Target date for achievement.

Field sampling was to begin in March and continue through October. Laboratory processing of field samples was to continue concurrent with field sampling. Taxonomic identification of specimens was planned to begin in November and be completed by the end of December. Data processing and report preparation were scheduled for January and February.

c. Date of accomplishment.

The field work was completed as scheduled and laboratory processing was accomplished as planned. Taxonomic work was completed for all areas except aquatic insect samples.

d. Significant deviations.

None.

e. Remarks

Table 1 is a listing of Missouri River collection sites. Table 2 lists numbers of fish by species by county for daytime electrofishing effort. Catch per unit effort (CPUE) is similar to 1989 data. Highest density occurred in Washington County (channelized) in both years and the lowest was in Boyd County (unchannelized).

Table 1. Site coding for Missouri River and tributary collection sites.

Site Code	Ramp Mile	County	Town	Downstream R.M.	Upstream R.M.	R.M. of mouth
1	866	Boyd	Sunshine Bottom (Lynch)	862	872	
2	841	Knox	Niobrara	834	855	
3	816	Knox	Lewis & Clark Lake	811	830	
4	810	Cedar	Gavins Point Tailwater	806	810	
5	799	Cedar	St. Helena	793	806	
31	787	Clay, SD	Myron Grove (Gayville)	787	793	
6	785	Cedar	Brook Bottom (Wynot)	782	787	
32	780	Clay, SD	Clay County Park (Vermillion)	776	782	
30	776	Dixon	Maskel	772	776	
33	764	Union	Bolton Bend	759	772	
7	753	Dixon	Ponca	751	759	
34	753/732	Dixon/Dakota	Stabilized M.R.	734	751	
8	732	Dakota	South Sioux City	728	734	
29	726	Dakota	Dakota City	729	728	
35	?	Thurston	?	698	719	
9	691	Burt	Decatur	680	698	
10	673	Burt	Tekamah	664	680	
11	648	Washington	Blair	638	664	
26	628	Douglas	Dodge Park	615	638	
27	601	Sarpy	Bellevue	595	615	
25	591	Cass	Plattsmouth	577	595	
12	563	Otoe	Nebraska City	552	577	
28	542	Nemaha	Peru	541	552	
13	535	Nemaha	Brownville	516	541	
14	498	Richardson	Rulo	490	516	
39	885	Charles Mix	Fort Randall, SD	880	885	
15	843		Niobrara River			844
16	799		James River			800
17	776		Vermillion River			772
18	732		Big Sioux River			734
36	732		Floyd River			731
19	673		Little Sioux River			669
20	673		Soldier River			664
37	628		Boyer Chute			638
21	628		Boyer River			635
22	591		Platte River			595
38	542		Nishnabotna River			542
23	535		Little Nemaha River			528
24	498		Big Nemaha River			495

Table 2. Daytime electrofishing collections from 13 locations along the Missouri River during 1990.

SPECIES	NEMAHA	CASS	DAKOTA	KNOX	BOYD	CEDAR	BURT	LIT SIOUX	CLAY	WASHINGTON	OTOE	LIT NEMAHA	FT RANDALL
Shovelnose sturgeon	1	1	-	-	-	-	-	-	-	-	-	-	-
Paddlefish	-	-	1	-	-	-	-	-	-	-	-	-	-
Shortnose gar	1	-	1	1	-	-	-	-	-	-	-	-	-
Gizzard shad	3	3	10	-	13	9	11	2	1	-	-	-	-
Goldeye	5	1	19	-	-	1	11	2	-	5	12	2	-
Northern pike	-	-	-	2	-	-	-	-	-	-	-	-	-
Carp	11	-	34	38	1	28	19	-	1	70	89	3	-
River carpsucker	7	14	6	50	1	1	9	2	1	1	11	-	-
Blue sucker	-	-	8	-	-	18	8	-	-	-	12	-	-
Smallmouth buffalo	-	-	8	-	-	1	3	-	-	-	1	-	2
Bigmouth buffalo	3	-	2	4	-	3	1	-	1	-	5	-	23
Shorthead redhorse	-	-	5	1	1	5	1	-	-	-	-	-	-
Channel catfish	3	-	2	2	-	-	-	-	-	-	1	-	-
Flathead catfish	-	-	10	-	-	-	17	-	-	-	22	-	-
Stonecat	-	-	-	-	-	-	1	-	-	-	-	-	-
White bass	-	-	4	-	1	1	-	-	-	-	-	-	-
Largemouth bass	-	-	-	2	-	-	-	-	-	-	-	-	-
Smallmouth bass	-	-	-	1	1	1	-	-	-	-	-	-	-
Bluegill	-	-	-	-	1	1	-	-	-	-	-	-	-
Black crappie	-	-	-	5	-	-	-	1	-	-	-	-	-
Sauger	-	-	2	-	-	-	1	-	-	-	-	-	-
Walleye	-	-	-	-	-	1	-	-	-	-	-	-	-
Freshwater drum	2	1	17	2	-	12	15	-	1	6	5	-	-
Total fish	36	20	128	108	19	82	97	7	5	82	158	5	25
Total species	9	5	15	11	7	13	12	4	5	4	9	2	2
Minutes	47	22	122	101	89	79	138	20	6	42	143	15	120
CPUE	0.8	0.9	1.1	1.1	0.2	1.0	0.7	0.4	0.8	2.0	1.1	0.3	0.2

Table 3 presents cheese baited hoopnet catch data. CPUE was lower in 1990 than in 1989.

Table 3. Cheese baited hoopnet collections by county from the Missouri River during 1990.

Species	Dixon	Cass	Cedar	Knox
Shovelnose sturgeon	-	-	1	-
Goldeye	1	-	-	-
Carp	-	-	-	3
River carpsucker	-	-	-	3
Blue sucker	15	1	-	-
Shorthead redhorse	2	-	3	3
Channel catfish	49	65	52	77
Flathead catfish	1	1	3	-
Green sunfish	1	-	-	-
Walleye	-	-	-	1
Freshwater drum	2	-	-	1
Total fish	71	67	59	88
Total species	7	3	4	6
Net/nights	22	18	16	30
CPUE	3.2	3.7	3.7	2.9

Table 4 lists species captured while seining in 1990. We are concerned about the lack of flathead chubs in our collections and by the small number of silvery minnows. Both species were abundant in the 1970's (Hesse and Wallace 1976). Collection effort will emphasize the location of flathead chubs during 1991 in order to obtain a status update. Seine CPUE is quite variable. A long term perspective may be necessary in order to understand cyprinid density dynamics.

Table 4. Seine collections from 10 locations along the Missouri River during 1990.

SPECIES	NEMAHA	DAKOTA	KNOX	BOYD	CEDAR	BURT	WASHINGTON	OTOE	DIXON	LEWIS&CLARK
Gizzard shad	-	9	17	1	12	9	-	1	5	7
Silvery minnow	-	-	-	-	-	-	-	43	-	-
Speckled chub	-	-	-	-	-	-	-	1	-	-
Silver chub	13	1	-	-	-	1	1	8	-	-
Emerald shiner	-	74	4	112	279	108	8	47	46	575
River shiner	-	28	2	-	36	14	-	39	3	-
Red shiner	-	50	16	2	4	4	-	8	10	-
Sand shiner	-	30	9	-	191	2	-	1	37	-
Fathead minnow	-	-	-	-	-	-	-	1	-	-
River carpsucker	-	4	10	-	43	33	1	12	64	-
Shorthead redhorse	-	-	-	14	2	-	-	-	5	-
Channel catfish	1	4	-	-	-	20	-	17	-	-
White bass	-	5	2	19	13	2	-	2	2	-
Largemouth bass	1	-	-	-	7	-	-	-	-	5
Smallmouth bass	-	-	1	10	-	-	-	-	-	6
Bluegill	-	-	-	81	-	-	-	-	-	-
Black crappie	-	-	-	7	-	-	-	-	-	-
Spotfin shiner	-	20	8	1	41	1	-	1	22	6
Johnny darter	-	-	-	1	-	-	-	-	1	-
Yellow perch	-	-	-	148	-	-	-	-	-	-
Freshwater drum	-	-	-	-	-	4	-	-	-	1
Spottail shiner	-	-	-	20	-	-	-	-	-	8
Total fish	15	225	69	423	621	198	12	181	195	608
Total species	3	10	9	13	9	11	5	13	10	7
Hauls	4	6	4	9	4	3	1	4	7	4
CPUE	3.8	37.5	17.3	47.0	155.3	66.0	12.0	45.3	27.9	152.0

Table 5 shows gillnet and trammel net data. CPUE in Knox County was down substantially. Paddlefish were collected in Boyd County which has not occurred in the recent past. This may reflect increasing density resulting from their protected status in this section of the river.

Table 5. Gillnet and trammel net collections by county from the Missouri River during 1990. Trammel netting occurred only in Cedar County and no gillnets were used in Cedar County.

Species	Nemaha	Knox	Boyd	Cedar
Shovelnose sturgeon	1	-	-	98
Paddlefish	1	-	2	-
Shortnose gar	-	1	7	-
Goldeye	8	-	-	-
Northern pike	-	8	2	-
Carp	-	6	-	-
River carpsucker	2	40	32	-
Smallmouth buffalo	-	11	2	-
Bigmouth buffalo	-	1	-	-
Shorthead redhorse	-	1	30	-
Black bullhead	-	3	-	-
Channel catfish	1	4	7	-
Largemouth bass	-	1	-	-
Smallmouth bass	-	-	1	-
Black crappie	-	1	-	-
Walleye	-	1	-	-
Total fish	13	78	83	98
Total species	5	12	8	1
Net/nights	2	5	2	4
CPUE	6.5	15.6	41.5	24.5

Table 6 includes the results of bottom trawling in Lewis and Clark Lake. Freshwater drum predominated the catch and only one paddlefish was captured in 1990. Young of the year sauger (21) and walleye (4) were captured. Sauger comprised 84% of the sauger/walleye sample.

Table 6. Trawl collections from Lewis and Clark Lake during 1990.

Species	Number
Paddlefish	1
Gizzard shad	80
Goldeye	1
Carp	4
Emerald shiner	3
Sand shiner	1
River carpsucker	11
Channel catfish	153
White bass	4
White crappie	4
Johnny darter	2
Sauger	21
Walleye	4
Freshwater drum	8,771
Spottail shiner	1
Total fish	9,061
Total species	15
Minutes	156
CPUE	58.1

Table 7 presents nighttime electrofishing results. Paddlefish were collected in April in Knox County near a rock lined shore. We imagine these rocks served as a spawning substrate.

Table 7. Nighttime electrofishing from three locations along the Missouri River during 1990.

Species	Knox	Cedar	Randall
Paddlefish[1]	3	1	-
Gizzard shad	-	7	-
Goldeye	-	17	-
Brown trout	-	-	2
Northern pike	-	-	1
Carp	2	2	-
River carpsucker	-	48	-
Quillback carpsucker	-	1	-
Blue sucker	-	6	-
Bigmouth buffalo	-	1	-
Shorthead redhorse	8	16	1
Channel catfish	5	-	1
White bass	-	3	-
Rock bass	-	4	-
Smallmouth bass	-	2	-
Sauger	4	-	1
Walleye	-	2	5
Freshwater drum	-	18	-
Total fish	21	128	10
Total species	5	14	5
Minutes	28	28	25
CPUE	0.8	4.6	0.4

[1] In addition to three paddlefish which were collected and tagged, 10 more were observed leaving the electrical field.

Table 8 presents a sample of fish acquired with deep water electrodes. Channel catfish are most commonly collected with this procedure.

Table 8. Deep water electrofishing using long electrodes by county from the Missouri River during 1990.

Species	Nemaha	Cass	Burt	Washington	Otoe
Carp	4	2	2	-	-
River carpsucker	-	-	-	8	-
Channel catfish	1	-	45	-	-
Flathead catfish	-	-	1	-	-
Freshwater drum	1	7	10	8	1
White amur	1	-	-	-	-
Total fish	7	9	58	16	1
Total species	4	2	4	2	1
Minutes	10	14	3	10	17
CPUE	0.7	0.6	19	1.6	0.1

Table 9 presents the larval fish collected during 1990; 45,560 larvae were collected from 115,450 m^3 of river water. CPUE was 395 larvae/1,000 m^3. The CPUE from the upper unchannelized reach was much lower than at all other sites. Drift net collections in 1989 produced 4,719 fish and 31,915 m^3 of water was filtered (Table 10). CPUE was 148 larvae/1,000 m^3. The highest CPUE for the three-year period occurred in 1988; 521 larvae/1,000 m^3 (27,635 fish from 53,009 m^3 of river water) (Table 11).

Table 9. Larval fish collections by collection site from the Missouri River during 1990. In some situations, collections were made from two sites in the same county. The volume filtered is in m^3 and CPUE is number per 1,000 m^3.

	Site								
Species	2	9	3	4	5	6	7	8	10
Paddlefish	1.0	6.8	-	-	-	-	-	-	-
Gizzard shad	-	25.8	564.2	473.8	291.7	34.6	30.6	55.5	41.9
Skipjack herring	-	4.3	-	-	-	-	-	-	-
Goldeye	-	10.5	-	-	-	-	-	1.0	23.2
Carp	42.1	72.0	26.6	83.5	51.2	10.8	80.7	199.8	102.4
Emerald shiner	25.8	25.9	4.6	43.3	7.6	3.5	3.6	3.9	3.9
Red shiner	-	-	-	-	4.5	-	-	-	-
River carpsucker	242.0	1185.0	114.1	85.3	315.4	395.5	227.1	907.3	299.4
Blue sucker	-	16.5	3.0	11.4	31.7	47.8	10.2	33.5	13.1
Smallmouth buffalo	7.0	-	-	-	3.7	3.6	-	-	-
Bigmouth buffalo	-	-	-	-	-	-	-	4.2	-
Shorthead redhorse	-	-	-	-	9.8	-	-	-	-
White bass	-	4.1	3.8	16.5	15.1	7.2	7.2	-	-
Bluegill	7.0	-	-	1.0	7.7	-	11.8	-	4.0
Black crappie	3.6	3.5	2.0	3.8	3.6	3.7	-	8.3	4.3
Sauger	33.8	7.6	8.8	5.2	28.4	11.1	4.2	8.1	3.9
Walleye	-	-	-	-	7.0	3.5	-	-	-
Freshwater drum	5.7	7395.8	142.1	7314.6	6875.6	989.2	1621.5	8317.6	6333.0
Rainbow smelt	-	8.2	-	-	-	-	-	-	-
Total fish	339	8768	870	8039	7665	1513	1998	9540	6828
Volume filtered	15383	14298	16089	16696	16167	9111	5547	15374	6785
CPUE	22	613	54	481	473	166	357	620	1004
CPUE w/o drum	21.6	96.0	45.2	43.4	48.9	57.5	68.0	79.5	73.0

Table 10. Larval fish collections by site from the Missouri River during 1989. The volume filtered is in m^3 and CPUE is number per 1,000 m^3.

	Site[1]										
Species	2	9	4	5	7	8	10	11	12	13	1
Paddlefish	8.0	-	-	-	-	-	-	-	-	-	-
Gizzard shad	-	-	10.8	12.6	4.0	4.0	-	-	-	-	-
Goldeye	-	-	-	-	-	-	-	-	20.0	-	-
Carp	160	38.0	56.8	141.0	44.2	56.8	4.1	4.0	8.2	16.3	-
Emerald shiner	-	-	30.1	-	-	-	-	8.0	-	-	-
River carpsucker	368	57.0	312.6	68.0	84.4	453.7	-	229.6	73.1	140.7	-
Smallmouth buffalo	-	-	-	168.0	-	16.4	41.0	-	-	-	-
Bigmouth buffalo	4	-	-	-	-	-	-	-	-	-	-
White bass	16	-	4.3	12.6	-	-	-	-	-	-	-
Bluegill	-	3.8	-	-	-	-	-	-	-	-	-
Black crappie	4	-	4.3	8.4	-	-	-	-	-	-	-
Sauger	-	-	12.9	16.0	8.2	4.1	-	4.1	-	4.0	-
Walleye	-	-	60.2	16.0	-	8.2	-	-	4.0	-	4.4
Freshwater drum	-	-	878.4	63.0	352.0	332.4	-	248.0	4.1	4.0	-
Total fish	560	99	1370	506	492	875	45	494	109	165	4
Volume filtered	5005	1164	3665	3061	2790	4616	1174	2934	3204	2559	1743
CPUE	112	85	374	165	176	190	38	168	34	64	2.3
CPUE w/o drum	112	85	134	145	50	118	38	84	33	63	2.3

[1] Site 6 was sampled, 1,168 m^3 produced 0.0 fish.

Table 11. Larval fish collections by site from the Missouri River during 1988. The volume filtered is in m^3 and CPUE is number per 1,000 m^3.

	Site [1]					
Species	2	9	4	5	7	8
Paddlefish	4.0	4.0	-	-	-	-
Gizzard shad	-	49.8	16.6	138.6	72.0	43.4
Skipjack herring	-	3.5	30.8	-	-	-
Goldeye	-	3.6	-	-	-	-
Carp	30.4	39.7	-	326.0	12.6	39.4
Emerald shiner	4.1	3.6	11.7	79.8	-	11.1
Sand shiner	-	-	-	-	-	-
River carpsucker	834.5	591.9	152.4	551.6	162.3	643.5
Smallmouth buffalo	-	-	-	808.1	-	-
Bigmouth buffalo	-	-	-	-	-	-
Shorthead redhorse	-	-	-	-	-	-
White bass	4.1	30.3	24.9	63.0	-	18.5
Bluegill	-	-	-	3.7	12.0	-
Black crappie	-	-	-	16.8	-	7.2
Sauger	22.8	-	-	34.7	-	8.4
Walleye	-	55.0	-	3.7	17.2	-
Freshwater drum	-	2388.3	916.1	619.3	832.0	4543.0
Total fish	900	3171	1153	2647	1108	5314
Volume filtered	5710	4691	3737	7954	3106	5159
CPUE	158	676	309	333	354	1030
CPUE without drum	158	167	63	255	86	150

[1] Site 6 was sampled - 1,418 m^3 produced 0.0 fish.

Table 11 continued. Larval fish collections by site from the Missouri River during 1988. The volume filtered is in m^3 and CPUE is number per 1,000 m^3.

	Site [1]					
Species	10	11	12	13	14	1
Paddlefish	-	-	-	-	-	-
Gizzard shad	30	81.0	30.9	8	37.8	-
Skipjack herring	-	-	-	-	-	-
Goldeye	1	135.0	376.0	216	34.0	-
Carp	5	12.0	13.1	3	22.0	-
Emerald shiner	-	17.0	79.8	4	-	-
Sand shiner	1	-	-	-	-	-
River carpsucker	127	448.8	295.5	143	149.6	-
Smallmouth buffalo	-	-	-	-	-	19.8
Bigmouth buffalo	-	3.0	-	6	-	-
Shorthead redhorse	-	1.0	-	1	-	-
White bass	6	13.0	7.6	16	-	-
Bluegill	-	9.0	-	-	-	-
Black crappie	-	-	-	-	-	-
Sauger	1	1.0	-	3	-	-
Walleye	-	43.2	-	-	2.0	-
Freshwater drum	3725	4004.0	1939.8	465	810.6	-
Total fish	3896	4768	2744	865	1057	20
Volume filtered	5160	5479	3311	1116	3803	3783
CPUE	755	870	829	775	278	5.3
CPUE without drum	33	139	243	358	65	5.3

[1] Site 6 was sampled - 1,418 m^3 produced 0.0 fish.

Freshwater drum larvae predominated each years catch (86% in 1990, 40% in 1989, 73% in 1988). River carpsucker made up 38% of the 1989 catch. This species is the second most dominate in each year. The separation of river carpsucker, smallmouth buffalo and bigmouth buffalo at the larval size has been difficult. It is likely that some fish identified as river carpsucker are actually buffalo. Sauger/walleye made up 0.3% of all 1990 larvae; 3% of 1989 larvae, and 0.7% in 1988.

Larval skipjack herring were collected for the first time in 1988 and then again in 1990. Rainbow smelt larvae were collected for the first time in 1990.

We spend most of our time filtering river water for larval fish, during the breeding period for native fishes of the Missouri River. Our first collection in 1990 was on 10 May and our last on 3 July. This 55-day period encompasses the portion of the breeding period when density is highest. We collected during 17 days (31%). Mean discharge from Gavins Point Dam for this period was 31,300 cfs or 886 m^3/s. There are 4.752 million seconds in this 55 day spawning period, multiplied by 886 m^3 each second equals 4.2 billion m^3 of river volume flowing past Gavins Point Dam during the 55 days of the spawning season (this applies to any point along our collection area). We filtered 115,450 m^3 in 1990, which is 0.00274% of the total volume of that period. Therefore, the 45,560 fish larvae we collected represented 0.00274% of the total fish larvae drifting during those 55 days. Expanded to the 55 day period, the total number of drifting larvae was about 1.663 billion. Hatching success of walleye, as an example, in the controlled environment of the North Platte State Fish Hatchery was 30% in 1989 (Annual Report 1989). Hatching success in the wild is undoubtedly much lower. Survival of fry in the hatchery ponds after 54 days was 21%. Survival of larvae in the wild is undoubtedly much less. It is unlikely that larval survival in the wild consistently exceeds 5% (Hesse and Mestl 1987). We can say, therefore, that 1.66 billion larvae represents 5% of the larvae hatched in the river, which is approximately 33 billion larvae. Moreover, 33 billion larvae may represent 30% (probably much less) of the eggs that were laid in 1990 in just 175 miles of river. Total egg production in this reach, even under the altered environment of the Missouri River today was at least 110 billion.

North Platte State Fish Hatchery calculated that it costs 1.6 cents to produce one walleye fingerling (Annual Report 1989). It required 27.5 eggs to produce one fingerling, therefore each egg is worth 0.06 cents. The Missouri River provided $66 million worth of fish eggs from just 175 miles of its length.

We had not aged any catfish since the early 1980's, therefore a small sample of spines (160) were collected and aged in 1990. Table 12 presents backcalculated growth data. The mean length of this sample from one-inch and one-and-a-half-inch mesh hoopnets was 304 mm total length. We will collect more spines from channel and flathead catfish during the next five years or more in order to monitor age distribution as it may relate to catfish management which will include a cessation of commercial fishing beginning in 1992.

Table 12. Backcalculated growth using the methods of Monastyrsky for channel catfish collected from the Missouri River during 1990.

Age	No.	Size at age class							
1	2	143.34							
2	30	97.11	177.98						
3	67	86.72	199.98	234.13					
4	16	95.40	178.16	250.12	299.75				
5	17	95.49	166.73	223.07	274.56	344.53			
6	17	99.70	166.56	213.29	264.49	309.96	347.63		
7	8	90.53	147.41	204.28	249.11	297.34	342.56	0.00	
8	3	105.91	160.44	235.13	266.48	298.60	330.08	402.17	402.17

Backcalculated length at age

	1	2	3	4	5	6	7	
	93.09	183.12	230.07	274.63	319.46	344.18	402.17	402.17
Number =	157	157	126	61	44	27	3	

Empirical length at age

	1	2	3	4	5	6	7	8
	-	228	262	334	384	393	428	488
Number =	-	30	67	16	17	17	8	3
CV (%)	-	11.3	10.8	14.0	9.0	11.5	8.4	20.8

Literature Cited

Annual Report. 1989. Fisheries Division annual report. Nebraska Game and Parks Commission, Lincoln, NE. 115 p.

Hesse, L.W. and G.E. Mestl. 1987. Ecology of unchannelized reaches of the Missouri River. Performance Report, Dingell-Johnson Project F-75-R-4, Nebraska Game and Parks Commission, Norfolk, NE. 57 p.

Hesse, L.W. and C.R. Wallace. 1976. The effects of cooling water discharges from Fort Calhoun and Cooper Nuclear stations on the fishes of the Missouri River. Final Report, Dingell-Johnson Project F-4-R, Nebraska Game and Parks Commission, Lincoln, NE. 38 p.

2. Job objective 1-4.

Acquire an annual estimate of angler pressure and harvest of paddlefish from the open area along the Nebraska-South Dakota border.

a. Activity.

Larval paddlefish were filtered from the drift and angler use of the paddlefish resource was measured by a complete census in Gavins Point Dam tailwater.

b. Target date for achievement.

Larval paddlefish were to be collected in May. The snagging season was during October.

c. Date of accomplishment.

The field season was completed as scheduled.

d. Significant deviations.

None.

e. Remarks.

Appendix A summarizes the results of these studies.

f. Recommendations.

Recommended management appears in the paper in Appendix A.

g. Cost.

Not available.

h. Acknowledgment.

Seasonal employees contribute greatly to our annual effort to acquire and analyze data. We would like to acknowledge Melanie Vorderstrasse, Theresa Smydra, and Cynthia Trail-Cooke for their dedicated contribution to Missouri River studies. We must also acknowledge Cathy Riggins and Penny Sutherland for typing the manuscripts.

Prepared by: Larry W. Hesse and Gerald E. Mestl
Aquatic Research Biologists

Reviewed by: Gene Zuerlein
Assistant Chief of Fisheries

Approved by: Wes Sheets
Chief of Fisheries

The status of paddlefish and the snag fishery in the Nebraska portion of the Missouri River.

Larry W. Hesse
Gerald E. Mestl
Melanie R. Vorderstrasse
Cynthia D. Trail-Cook

State of Nebraska
Game and Parks Commission
Fisheries Division

Federal Aid in Fish Restoration
Dingell-Johnson Project
F-75-R-8 Job No. 4

January 1991

Abstract

Larval paddlefish density declined in 1990 from 1989 and y-o-y indices were similar to the larval density. Larval paddlefish were collected from a channelized site in 1990. Mean length and weight of snagged paddlefish was higher in 1990 compared with 1989 and the percent of 10-year old or older paddlefish increased to 15% from 13%. Backcalculated growth is fastest between age 1 and 2 and declined thereafter. Total mortality was very high after age 6 and the rate of exploitation was estimated to be nearly 20%. The total harvest in the Gavins Point Dam tailwater was nearly 2,000 fish in 1990 which exceeded the quota trigger by double. Catch rate in 1990 was 0.33, nearly 50% greater than 1989. Management plans for the next several years may include more harvest restrictions, closed areas, better procedures to manage the season closure and the implementation of a protected slot limit. Management objectives include halving of the exploitation rate and doubling the percentage of 10-year and older paddlefish in this population.

Key Words: Life history, larvae, snagging, water level control, exploitation, age distribution, length-frequency, creel survey, slot limit, fishing success, regulations.

Introduction

Even though paddlefish populations are declining throughout their range in North America, some populations are still fished commercially. This most likely results from insufficient knowledge regarding the status of individual populations, but also because of the lack of a coordinated national study of their interstate movements in search of suitable habitat. We discussed the possibility that paddlefish were moving in and out of the Missouri River in 1989 (Hesse et al. 1989). Since then more data has been gathered from the local population and the evidence continues to accumulate that the Nebraska-South Dakota population may be highly mobile and composed of elements from other populations such as the Mississippi or it's other tributary streams.

The 1990 snagging season was the second year of a 1,600 fish harvest quota. The 1991 season will be the first year of a three-year harvest plan which will restrict harvest even more, leading toward achievement of our stated management goals.

Acknowledgement

Creel census duties during the 1990 snagging season were divided among the authors as well as biologists from South Dakota. The supervisory fisheries biologist for South Dakota was Cliff Stone, additional staff included: his assistant, Gerald Wickstrom, and technicians Phillip Sensenbaugh and Wayne Stasny. In addition, Dennis Unkenholz (South Dakota Missouri River Coordinator) assisted at a check station on opening day.

Methods

Check stations were set up on access roads into the Gavins Point Dam tailwater area from both the north and south banks. All fishermen entering and leaving the tailwater by vehicle were stopped and interviewed. This same procedure was followed in 1989 and fishermen were often required to wait from 5 to 30 minutes in order to check out of the station, because of the large number of fishermen during the short snagging season.

Eye to fork length (EF) (mm) and weight (g), of most paddlefish was recorded. Jaws for age determination were collected during the opening day from all paddlefish entering the south bank check station. The tip of the rostrum was removed from all paddlefish shorter than 500 mm EF and these snouts were X-rayed by a veterinarian to locate any coded wire tags which may have been present. Gavins Point National Fish Hatchery has stocked hatchery raised paddlefish that were tagged with a one-mm coded wire tag since 1988. To date, all hatchery reared paddlefish have been stocked upstream from Gavins Point Dam.

During the final three days of the season, paddlefish were sexed at the south bank check station by visual inspection of gonads through an incision in the abdomen.

All information obtained from snag fishermen was recorded on a three-part form (the same as used in 1989). Nebraska and South Dakota each received a copy and the fishermen were presented the card portion for a personal record of their fishing trip. In instances where their fish would qualify for a Master Angler Award, the bottom card was signed and retained by the clerk. We submitted all of these cards after the season as a service to the fishermen.

Extensive larval fish drift sampling occurred during 1990 and larval paddlefish were sorted from other species collected. The samples were acquired by twin net tows at cutting, filling and mid-channel locations with one-meter diameter, conical plankton nets (560 micron openings). Weekly collections were made at five sites in the unchannelized and channelized sections.

Young-of-the-year (y-o-y) paddlefish were collected from Lewis and Clark Lake using a 26 foot (headrope) semi-balloon, otter trawl. The collections were made in late July and early August.

Adult paddlefish were tagged just before the start of the 1990 snagging season in order to evaluate the rate of exploitation and to obtain a rough estimate of population size. Three-inch mesh multifilament gill nets were fished near the bottom and at the surface in the quiet water of the Gavins Point Dam stilling basin. The nets were anchored and lifted every half hour.

Results

Larval paddlefish were collected from the Missouri River between 1975 and 1981 (Unkenholz 1982), and between 1983 and 1989 (Hesse et al 1990). The results of drift netting in 1990 were added to the 1983-1989 data in Table 1. We filtered 115,449 m^3 (30.5 million gallons) of river water during 1990 and collected eight paddlefish larvae. Seven of these were collected from the channelized river near Decatur, NE, (RM 691) while the remaining larva was collected near Niobrara (RM 841) in the upper unchannelized. During 1989, eight larvae were collected but all were collected from Niobrara. The Decatur site produced four and four larvae came from near Niobrara in 1988. In 1987 we were only able to capture one paddlefish larva and it was from Niobrara. In 1986 three larval paddlefish were from the tailwaters of Gavins Point (RM 810) and one was from the unchannelized river near St. Helena (RM 799). The St. Helena site produced the only two larvae collected in 1985, and the only larva collected in 1984. The number of paddlefish larvae per 1,000 m^3 had steadily increased from 1983 through 1989 (except for 1987) in our total sample as well as from the upper unchannelized until 1990 when the catch dropped precipitously.

Table 1. Number of paddlefish larvae collected annually from 1983 through 1990, including the volume of water filtered (m^3) and the CPUE (no. of larvae/1000 m^3), Missouri River, Nebraska.

Year	No. of larvae[1]	Volume filtered[1]	CPUE[1]
1983	0	12,698 (7,215)	0.0 (0.0)
1984	1 (0)	69,630 (16,708)	0.01 (0.0)
1985	2 (0)	87,046 (15,296)	0.02 (0.0)
1986	4 (0)	48,190 (2,393)	0.08 (0.0)
1987	1 (1)	29,368 (5,042)	0.03 (0.2)
1988	8 (4)	54,430 (9,499)	0.15 (0.42)
1989	8 (8)	33,472 (6,749)	0.24 (1.19)
1990	8 (1)	115,449 (15,383)	0.07 (0.07)

[1] These data include samples from all collecting sites in the Missouri River in Nebraska. The values in parentheses are for the unchannelized section upstream from Lewis and Clark Lake.

Fewer y-o-y paddlefish were caught while trawling in 1990 (Table 2) than in most previous years. The highest trawl CPUE occurred in 1988 and 1989 when larval density was also highest.

Table 2. Number of paddlefish y-o-y collected annually with a bottom trawl from Lewis and Clark Lake from 1986 through 1990. CPUE equals the number of y-o-y paddlefish per minute of trawl time.

Year	Minutes trawled	No. of y-o-y	CPUE
1986	150	35	0.23
1987[1]	539	15	0.03
1988[1]	120	75	0.63
1989	67	25	0.37
1990	104	4	0.04

[1] 1987 and 1988 data were provided by James C. Schmulbach and Scott Wessel, University of South Dakota, Vermillion.

The mean length, mean weight, and percentage of fish 10-years or older increased from 1989 to 1990 (Table 3). We believe that many of the paddlefish shorter than 1,000 mm EF that were sexed may have been sexed incorrectly. Apparently an immature ovary resembled a testis sufficiently to cause mistaken identification. Ovaries in females longer than 1,000 mm EF were usually gravid. We utilized only those longer than 1,000 mm EF and found 70% were females. We plan to extract a small sample of gonads next year for identification in the laboratory.

Table 3. Life history statistics of paddlefish snagged from 1987 through 1990.

	1987	1988	1989	1990
Number of fish measured	87	1,321	1,217	1,613
Mean eye to fork length (mm)	705	749	695	739
Number of fish weighed	87	796	1,210	1,510
Mean weight (kg)	4.67	7.84	6.28	6.89
Mean K-factor	1.17	1.49	1.41	1.29
Number of fish aged	368	387	578	286
% Ten years or older	6.5	14.5	12.8	15.3
Number of fish sexed			136	57
Number of females (%)			54 (40)	40 (70)
Mean length of female			817	na
Mean weight of female			10.9	na
Number of males (%)			82 (60)	17 (30)
Mean length of male			737	na
Mean weight of male			6.4	na

Table 4 presents the length-weight relationship for the past four years. Table 5 is a listing of predicted weight using the 1990 regression coefficient.

Growth measurements were made from each jaw sample in 1990. The correlation between jaw radius and body length was best described by a curvilinear relationship (Table 4). We re-aged about 50 fish from 1987, 1988 and 1989 jaw samples and reported the jaw radius - body length relationships in Table 4. The 1990 data had the best correlated relationship as demonstrated by an r^2 value of 0.79. Most likely small sample size contributed to the poorly fitted data in other years. On this basis we will report on backcalculated growth using only 1990 data.

Table 4. Paddlefish length-weight (L-W) relationship and jaw radius - body length (J-L) relationship, Missouri River in Nebraska, 1987 through 1990.

	Slope	y-intercept	r^2
1987 L-W	0.0175	-7.6513	0.85
1988 L-W	0.0340	-17.9835	0.82
1989 L-W	0.0252	-11.0758	0.76
1990 L-W	0.0255	-12.1845	0.77
1987 J-L	0.0929	461.1671	0.13
1988 J-L	-0.0419	791.3794	-0.09
1989 J-L	0.1942	363.9992	0.34
1990 J-L	0.3981	167.4970	0.79

Table 5. Predicted weight and K-factor of paddlefish from the Missouri River in Nebraska at 100 mm increments of body length (EF), using the slope of the length-weight equation.

Class interval mm	weight (kg)	K-factor
100	0.01	-
200	0.10	-
300	0.33	1.2
400	0.80	1.4
500	1.57	1.5
600	2.73	1.2
700	4.36	1.2
800	6.54	1.2
900	9.36	1.1
1000	12.90	1.5
1100	17.23	1.4
1200	22.46	1.2

Table 6 presents a length-frequency distribution for 1,613 paddlefish snagged from the Gavins Point Dam tailwater in 1990. Table 7 is the weight-frequency distribution. Table 8 is an age distribution for 296 paddlefish from 1990, including precent frequency by age-class. Table 9 is a backcalculated growth table for 1990 snagged paddlefish. The table includes mean backcalculated growth at ages 1 through 10, and also the observed mean length and mean weight for ages 1 through 10, and mean condition factor.

Table 6. Length-frequency of 1,613 paddlefish snagged by fishermen from the tailwater of Gavins Point Dam during 1990.

Length		Freq.	Cum. freq.	Percent	Cum. percent
125	I	2	2	0.12	0.12
150		0	2	0.00	0.12
175		0	2	0.00	0.12
200		0	2	0.00	0.12
225		0	2	0.00	0.12
250		0	2	0.00	0.12
275		1	3	0.06	0.19
300		1	4	0.06	0.25
325	IIIIII	16	20	0.99	1.24
350	IIIIIIII	20	40	1.24	2.48
375	IIIIIIIIIIIIIII	39	79	2.42	4.90
400	IIIIIIIIIIIIIIIIIIIIIIIII	65	144	4.03	8.93
425	IIIIIIIIIIIIIII	43	187	2.67	11.59
450	IIIIIIIIIIIIIII	39	226	2.42	14.01
475	IIIIIIIIIII	30	256	1.86	15.87
500	IIIIIII	18	274	1.12	16.99
525	IIIIIIIIIII	27	301	1.67	18.66
550	IIIIIIIIIII	30	331	1.86	20.52
575	IIIIIIIIIIIIIIIIIIIII	60	391	3.72	24.24
600	IIIIIIIIIIIIIIIIIIIIIIIII	71	462	4.40	28.64
625	IIIIIIIIIIIIIIIIII	53	515	3.29	31.93
650	IIIIIIIIIIIIII	39	554	2.42	34.35
675	IIIIIIIIIIIIIII	45	599	2.79	37.14
700	IIIIIIIIIIIIIIIIII	55	654	3.41	40.55
725	IIIIIIIIIIIIIIIIIIIIIIIIIII	78	732	4.84	45.38
750	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII	103	835	6.39	51.77
775	IIIIIIIIIIIIIIIIIIIIIIIIIIIIII	89	924	5.52	57.28
800	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIII	93	1017	5.77	63.05
825	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII	99	1116	6.14	69.19
850	IIIIIIIIIIIIIIIIIIIIIII	71	1187	4.40	73.59
875	IIIIIIIIIIIIIIIIIII	64	1251	3.97	77.56
900	IIIIIIIIIIIIIIII	53	1304	3.29	80.84
925	IIIIIIIIIIII	37	1341	2.29	83.14
950	IIIIIIII	22	1363	1.36	84.50
975	IIIIII	18	1381	1.12	85.62
1000	IIIIIIIII	24	1405	1.49	87.10
1025	IIIIIIIIIII	35	1440	2.17	89.27
1050	IIIIIIIIIIIIII	43	1483	2.67	91.94
1075	IIIIIIIIIIIIII	39	1522	2.42	94.36
1100	IIIIIIIIIIIIII	40	1562	2.48	96.84
1025	IIIIIIIIIII	31	1593	1.92	98.76
1150	IIII	9	1602	0.56	99.32
1175	II	6	1608	0.37	99.69
1200	II	5	1613	0.31	100.00

```
    ----+---+---+---+---+---+---+---+---+---+-
       10  20  30  40  50  60  70  80  90  100
                    Frequency
```

Table 7. Weight-frequency of 1,510 paddlefish snagged by fishermen from the tailwater of Gavins Point Dam during 1990.

Weight		Freq.	Cum. freq.	Percent	Cum. percent
0	1111111	34	34	2.25	2.25
1000	11111111111111111111111111111111111111	188	222	12.45	14.70
2000	1111111111111111111111111111111	159	381	10.53	25.23
3000	111111111111111111111111111	144	525	9.54	34.77
4000	11111111111111111111	115	640	7.62	42.38
5000	1111111111111111111111111111111	155	795	10.26	52.65
6000	11111111111111111111111111	134	929	8.87	61.52
7000	11111111111111111111111111	136	1065	9.01	70.53
8000	1111111111111	68	1133	4.50	75.03
9000	1111111	37	1170	2.45	77.48
10000	111111111	44	1214	2.91	80.40
11000	111111	32	1246	2.12	82.52
12000	111111	29	1275	1.92	84.44
13000	111	14	1289	0.93	85.36
14000	1111	18	1307	1.19	86.56
15000	11111	27	1334	1.79	88.34
16000	1111	22	1356	1.46	89.80
17000	1111	20	1376	1.32	91.13
18000	1111	19	1395	1.26	92.38
19000	11111	23	1418	1.52	93.91
20000	11111	23	1441	1.52	95.43
21000	11	11	1452	0.73	96.16
22000	11	11	1463	0.73	96.89
23000	11	11	1474	0.73	97.62
24000	11	8	1482	0.53	98.15
25000	11	9	1491	0.60	98.74
26000	1	7	1498	0.46	99.21
27000	1	5	1503	0.33	99.54
28000		2	1505	0.13	99.67
29000		2	1507	0.13	99.80
30000		1	1508	0.07	99.87
31000		0	1508	0.07	99.87
32000		0	1508	0.07	99.87
33000		1	1509	0.07	99.93
34000		0	1509	0.00	99.93
35000		1	1510	0.07	100.00

----+---+---+---+---+---+---+---+---+---+---
20 40 60 80 100 120 140 160 180
Frequency

Table 8. Age distribution of 296 paddlefish snagged from the tailwater of Gavins Point Dam during 1990.

Class	Freq.	Cum. freq.	Percent	Cum. percent
68 11	2	2	0.68	0.68
69	0	2	0.00	0.68
70	0	2	0.00	0.68
71 1	1	3	0.34	1.01
72 11	2	5	0.68	1.69
73 111	3	8	1.01	2.70
74 111	3	11	1.01	3.72
75 11	2	13	0.68	4.39
76 11111111111	11	24	3.72	8.11
77 111111	6	30	2.03	10.14
78 111111111	9	39	3.04	13.18
79 1111111111	10	49	3.38	16.55
80 1111	4	53	1.35	17.91
81 1111111111	10	63	3.38	21.28
82 1111111111111111111111	22	85	7.43	28.72
83 11111111111111111111111111111111	33	118	11.15	39.86
84 1111111111111111111111111111111111111111	41	159	13.85	53.72
85 11111111111111111111111111111111111111111111	43	202	14.53	68.24
86 111111111111111111111111111111111111	36	238	12.16	80.41
87 1111111111111111111111111111111111111	37	275	12.50	92.91
88 11111111111111111	18	293	6.08	98.99
89 111	3	296	1.01	100.00

-----+----+----+----+----+----+----+----+---
5 10 15 20 25 30 35 40

Frequency

Table 9. Backcalculated growth of Missouri River paddlefish collected in 1990 using the method of Monastyrsky (1930).

Age	No. fish	Size at age									
1	14	330.47									
2	29	302.75	434.67								
3	31	303.66	473.77	588.11							
4	41	296.64	478.04	596.90	663.74						
5	35	303.13	497.27	610.19	684.79	711.00					
6	33	292.03	487.89	601.83	684.04	741.21	749.97				
7	20	343.79	491.52	610.61	681.52	740.53	784.68	0.00			
8	10	303.50	473.45	578.64	664.30	727.57	773.18	839.99	839.99		
9	2	317.90	516.62	634.52	727.21	788.52	830.57	872.83	872.83	895.27	
10	39	288.05	447.27	558.25	633.25	688.69	728.94	788.97	788.97	807.89	825.95

	Mean backcalculated length at age.									
	1	2	3	4	5	6	7	8	9	10
	303.21	472.64	592.21	667.68	718.47	752.54	802.26	802.26	812.15	825.95
No. =	253	239	210	179	139	104	51	51	41	39

Table 9 Continued. Backcalculated growth of Missouri River paddlefish collected in 1990 using the methods of Monastyrsky (1930).

Mean empirical length at age

	1	2	3	4	5	6	7	8	9	10
FL. =	413.6	473.2	661.2	701.8	761.0	796.9	849.8	905.8	-	979.8
No. =	12	27	29	39	33	31	18	8	-	37
CV(%)=	17.1	17.5	16.4	13.6	12.2	12.6	9.8	7.5	-	14.7

Mean empirical weight at age

	1	2	3	4	5	6	7	8	9	10
No. =	1,013	1,556	3,963	4,764	5,466	6,415	8,233	9,409	6,810	11,191
Wt. =	15	31	36	43	38	33	22	10	2	10
CV(%)=	69	49	50	40	36	44	48	33	47	35

Mean K-factor at age

	1	2	3	4	5	6	7	8	9	10
K-factor =	1.22	1.39	1.35	1.28	1.19	1.21	1.32	1.24	-	1.40
CV (%) =	30	24	18	15	17	16	23	18	-	23

The percentage composition between age groups can be used to calculate instantaneous and total annual mortality and survival (Ricker 1975). Table 10 presents these data. Age groups 0 through 3 were not fully recruited to the snag fishery; therefore, mortality estimates are available only for ages 4 through 9.

Table 10. Percent instantaneous mortality (I) annual total mortality (A) and survival (S) among paddlefish age classes that were fully vulnerable to snagging during 1990.

Age	% Comp.	LOGE	I	A	S
4	16.1	2.78			
			16	15	85
5	13.8	2.62			
			6	6	94
6	13.0	2.56			
			50	39	61
7	7.9	2.06			
			69	50	50
8	3.9	1.37			
			99	80	20
9	0.8	-0.24			

The authors, with assistance from Cliff Stone, Gerald Wickstrom, Jim Schmulbach (biology professor at U.S.D., Vermillion, S.D.), and 3 graduate students, tagged 68 adult paddlefish in the Gavins Point Dam tailwater area. One hundred ninety gill net hours were expended between 1 October and 11 October, 1990. The objective was to obtain an estimate of exploitation rate and population density in the tailwaters. Estimated harvest in the Gavins Point Dam tailwater was 1,927 paddlefish between 15 October and 18 October, 1990 (Table 11); 16 tags were returned to the check stations. This suggests an exploitation rate of 24% and a relative population estimate of 8,029 paddlefish in the tailwater area. The pre-set harvest quota of 1,600 is 20% of the estimated population size. Pitcher and Hart (1982) have suggested that harvest may not exceed 8% of production and still maintain maximum sustained yield. We have not calculated annual production of paddlefish, however, harvest may nearly equate production in a heavily fished population (Welcomme 1985). Since our present quota represents 20% of the estimated population size, this suggests our quota is still too liberal.

We collected 372 rostrums during 1990 and found 2 with coded wire tags. One tag was recovered and was found to be from the 1989 year class. The other tag could not be recovered.

The actual harvest during 1990 in the tailwater area was 1,743 (Table 11); however, we conducted random spot checks at downriver access points after opening day and found that

many paddlefish were leaving the tailwaters in boats coming up from the Yankton access. These fish were not checked through tailwater check stations. We conservatively estimate that 180-200 paddlefish were probably snagged in the tailwater and removed at the Yankton ramp. Congestion at tailwater boat ramps and delays at check stations most likely prompts some snag fishermen to enter the river downstream and drive the short distance to the tailwater by boat. Spot checks at other access sites demonstrated that some harvest occurred downriver as well. Our harvest goal for 1990 was substantially exceeded.

Table 11. Gavins Point Dam paddlefish snagging season census information for each of the four days in the 1988-1990 seasons.

1990

Day	No. of paddlefish	Man-hours	Catch rate	No. of fishermen	Percent successful
1	877	2,814	0.31	1,055	83
2	399	1,289	0.31	590	68
3	196	459	0.43	259	76
4	271	777	0.35	428	63
Total	1,743	5,339	0.33	2,332	75

1989

Day	No. of paddlefish	Man-hours	Catch rate	No. of fishermen	Percent successful
1	807	3,460	0.22	1,095	74
2	199	830	0.22	363	55
3	151	630	0.23	276	55
4	207	643	0.31	315	66
Total	1,364	5,563	0.25	2,049	67

1988

Day	No. of Paddlefish	Man-hours	Catch rate	No. of fishermen
1	1,150	2,684	0.43	742
2	257	1,125	0.23	340
3	113	582	0.19	211
4	134	784	0.17	233
Total	1,654	5,175	0.26	1,526

Success rate in 1990 was much higher than in 1989 (Table 11). The opening day catch rate (0.31 fish per hour) was up by 50% over opening day catch rate in 1989 (0.22). Overall catch rate was better in 1990 than the past two years.

Interest in snagging continues to increase. An additional 14,708 miles were driven by snag fishermen in 1990 (Table 12) from the peak in 1988. Nebraskan's once again were out in front in the number of fishermen, number of trips, and miles driven to fish. In this respect, very little change occurred between 1989 and 1990, geographically.

Table 12. Geographic distribution of fishermen interviewed in the Gavins Point Dam tailwater including number and percent of individual fishermen, number of trips, and estimated travel distance by state in 1988, 1989 and 1990.

1988

State	Number	%	Trips	%	Estimated travel	%
Nebraska	898	51	1,198	49	240,244	76
South Dakota	508	29	868	36	25,836	8
Iowa	99	6	117	5	26,942	9
Kansas	5	1	13	1	8,308	3
Oklahoma	2	1	5	1	5,364	2
Michigan	2	1	2	1	3,712	1
Oregon	1	1	1	1	3,270	1
Minnesota	2	1	2	1	980	1
North Dakota	1	1	1	1	498	1
Colorado	2	1	2	1	Unknown	
Unknown	227	13	227	9	Unknown	
Total	1,747		2,426		315,154	

1989

State	Number	%	Trips	%	Estimated travel	%
Nebraska	930	62	1,152	56	212,382	81
South Dakota	501	34	878	40	29,208	11
Iowa	49	3	57	3	11,054	4
Minnesota	7	1	7	1	3,354	1
North Carolina	1	1	1	1	2,760	1
Colorado	1	1	2	1	2,184	1
Kansas	1	1	1	1	576	1
Total	1,490		2,048		261,518	

Table 12 Continued. Geographic distribution of fishermen interviewed in the Gavins Point Dam tailwater including number and percent of individual fishermen, number of trips, and estimated travel distance by state in 1988, 1989 and 1990.

	1990					
State	Number	%	Trips	%	Estimated travel	%
Nebraska	947	61	1,321	57	250,246	76
South Dakota	541	35	904	39	38,446	12
Iowa	53	3	80	3	17,074	5
Minnesota	8	1	11	1	6,936	2
North Dakota	3	1	6	1	4,584	1
California	2	1	2	1	6,600	2
Washington	1	1	4	1	3,200	1
Connecticut	1	1	2	1	2,200	1
Kansas	1	1	1	1	576	1
Unknown	5	1	5	1	Unknown	1
Total	1,562		2,336		329,862	

Discussion and Recommendations

Larval paddlefish density was relatively high in 1988 and 1989, especially in the upper unchannelized section (Site 1). In 1990 the collection site near Decatur, Ne., yielded seven of the eight larvae collected. We have collected paddlefish larvae at Decatur in previous years. The fact that we collected paddlefish at Decatur but didn't at South Sioux City in 1990 suggests that the larvae were from the channelized reach and not the unchannelized west of Sioux City. The Decatur area has had some barge groundings in recent years as a result of sand-bar development in the channel cross-section. This may be where the breeding has occurred. Another factor is the increased percentage of 10-year and older fish in the population east and south of Gavins Point Dam. In past years no larvae in our samples may have been a reflection of few breeding age females. The variable nature of larval production in the upper unchannelized section points to the importance of water management that is sensitive to native fish needs.

When we plotted the sex by length sorted by length, it became obvious that immature females were mis-identified as males until a size of 1,000 mm EF was reached. Beyond this size the females were gravid. We reported the ratio of these fish only, but plan to obtain a sample of the gonad from all size classes next year for laboratory identification.

The increase in mean length, mean weight and older fish is a management objective. It's too early to tell if this has resulted in part from our management plan.

Backcalculated growth in length shows the fastest growth occured between age 1 and 2 (170 mm) and then a steady decrease: 2 to 3 (120 mm), 3 to 4 (75 mm), 4 to 5 (51 mm), 5 to 6 (34 mm), 6 to 7 (50 mm), 8 to 9 (10 mm), 9 to 10 (12 mm).

Mortality is very high for seven and eight year old paddlefish. Harvest reduction at this point of the population structure would increase the total population size of older fish rather quickly. A protected slot length limit should start at about 800 mm EF; such a fish would weigh 6.5 kg. The upper limit of the slot must be well beyond the point where sexual maturity begins. Since most females longer than 1,000 mm were gravid, we suggest the top should be set at 1,200 mm EF; such a fish will weigh 22.5 kg.

The evidence gathered during 1990 would suggest that a 1,600 fish harvest quota is still too high, however closing portions of the open fishing area may reduce total harvest. We recommend maintaining the quota for several more seasons. However, we suggest that a maximum season length be set at seven days in addition to the quota, this would take affect in 1992. The season would close after reaching either the quota or after seven days of fishing. Management will include a closure of the cement wall, stilling basin, and discharge canal to all paddlefish harvest (snagging and archery) in 1991. This rule has been adopted and will be in effect in 1991.

We recommend the implementation of a protected slot limit for 1992. Any paddlefish caught that measures between 35 inches eye to fork to 45 inches eye to fork must be released. All other paddlefish, whether smaller or larger must be kept and counted in the bag. Moreover, we recommend that all archery paddlefishing should end, effective 1 January 1992.

It is essential that stricter control of harvest be implemented as we near the quota. South Dakota is restricted to 48 hours public notice before closure of the season. Nebraska does not have the same restriction. We propose that since the tailwater is totally in Nebraska, that Nebraska should post the tailwater closed when the quota is imminent, followed by closure of the remainder of the open area 48 hours later. The discussion of when to close the tailwater should still be made by the two state's biologists in the tailwater. It should not be closed mid-day but rather the end of the current day the quota will be reached.

Since boat snaggers may still fish the tailwater in 1991, we request that South Dakota man a check station at the Yankton ramp to count the fish taken in the tailwater but removed at Yankton. No other data would be necessary; however, the number caught should be counted in the tailwater tally.

Stewart (1987) reported a three year average angler exploitation rate of 6.8% for Intake, Montana paddlefish. Although this was higher than previous rates, Stewart was confident that there would not be a deleterious consequence of this harvest rate. We propose that through harvest restrictions and reproduction enhancement (the latter may be a consequence of effective stocking and adjusted water management), exploitation of the population downstream from Gavins Point should be reduced to no more than 10% in the short term but even less in the long term. Eighty three percent of Montana's paddlefish at Intake in 1985 were 10 years or older (Stewart 1987), while 15% of our population is 10 years or older. In the short term we should hope to achieve 30% 10-years or older and 50% or better for the long term.

Literature Cited

Hesse, L.W., G.E. Mestl, and D.G. Schumacher. 1989. The status of paddlefish and the snag fishery in the Missouri River from Lewis and Clark Lake to the Big Sioux River. Progress Report, Dingell-Johnson Project F-75-R-6, Nebraska Game and Parks Commission, Norfolk, NE., 57 pp.

Hesse, L.W., G.E. Mestl, P.A. O'Brien, and J.P. Cassidy. 1990. The status of paddlefish and the snag fishery in the Missouri River from Lewis and Clark Lake to the Big Sioux River. Progress Report, Dingell-Johnson Project F-75-R-7, Nebraska Game and Parks Commission, Norfolk, NE., 40 pp.

Monastyrsky, G.M. 1930. Uber Methoden zur Bestimmung der linearen Wachstums der Fische nach der Schuppe. Rept. Sci. Inst. for Fish Cult., 5(4); 3-44. (Moscow).

Pitcher, T.J. and P.J.B. Hart. 1982. Fisheries Ecology. AVI Publishing Co. Westport, CT., 414 pp.

Ricker, N.E. 1975. Computation and Interpretation of Biological Statistics of Fish Populations. Bulletin 191, Department of the Environment, Fisheries and Marine Service, Ottawa, Canada, 382 pp.

Stewart, P.A. 1987. Paddlefish investigations. Progress Report, Dingell-Johnson Project F-30-R-23, Montana Department of Fish, Wildlife and Parks, Helena, MT., 11 pp.

Unkenholz, D.G. 1982. Paddlefish spawning movements and reproductive success in the Missouri River below Fort Randall Dam, 1979-1981. Completion Report No. 82-3, Department of Game, Fish and Parks, Pierre, SD, 17 pp.

Welcomme, R.L. 1985. River Fisheries. FAO Technical Paper 262. United Nations, Rome, 330 pp.

Walleye in the unchannelized Missouri River in Nebraska

Larry W. Hesse
Gerald E. Mestl

State of Nebraska
Game and Parks Commission
Fisheries Division

Federal Aid in Fish Restoration
Dingell-Johnson Project
F-75-R-8 Job No. 1

January 1991

Abstract

Walleye were introduced into Nebraska's streams and lakes beginning in 1884. It is doubtful that they were native to these areas before 1884. Stream impoundment occurred during the 1900's and habitat for walleye was created as a result. Recent stocking effort in remnant flowing portions of the Missouri River has not proven successful in impacting year-class development. Walleye abundance as well as most native fishes in these reaches of river are declining as a result of ecosystem damage. The mean length of walleye in unchannelized sections has declined, most likely because of intensified fishing pressure. It is recommended that environmental problems should be addressed, fry/fingerling stockings should be phased out, and bag limits reduced with a requirement that all walleye caught should be kept and counted in the bag.

Key Words: Fry, fingerling, stocking, fishing pressure, length-frequency measurement, year class, netting, water management, flooding, turbidity.

Introduction

Walleye and its close relative, the sauger, are important food and game fishes. Management of these species is often difficult because of the high demand and altered natural environments. A perspective on the distribution and requirements of the walleye versus the sauger may be of some benefit as new management plans are contemplated. The explorers, Lewis and Clark, captured and described what Evermann and Cox (1896) identified as sauger from the Missouri River near Great Falls and from near the mouth of the Marias River, both in Montana. Dr. George Suckley collected sauger in 1860 from the Milk River, a tributary in Montana (Evermann and Cox 1896). Jordan and Meek (1885) explored a number of streams, including the Missouri River in 1884, from which they collected and described 22 species of fish near St. Joseph, Missouri. Sauger but not walleye were represented. Walleye and sauger were collected from the Big Sioux River near Sioux Falls, South Dakota, by Meek from collections made during 1889 to 1891 (Evermann and Cox 1896). Sauger were collected by Carl Eigenmann in 1892 from the Poplar River, a tributary in Montana, but no walleye (Evermann and Cox 1896). Dr. Meek collected saugers from the Floyd and Platte Rivers in 1892 and walleye from West Okoboji Lake in Iowa (Evermann and Cox 1896). Herbert Fisher conducted fish surveys of the Missouri River in Missouri during 1945; six sauger and one walleye were collected while seining (Fisher 1945).

Cross (1967) suggested that the earliest observations of walleye do not provide conclusive evidence that they were indigenous to the Kansas/Nebraska area, because they were being stocked as early as the first inventories of native fishes were being made. Walleyes were stocked prior to 1885 (Cross 1967) in Kansas and 1884 in Nebraska (Jones 1963).

According to Cross (1967), if walleye were native to Kansas Rivers, its habitat was marginal and he suggests that dam construction resulting in large impoundments created more habitat for walleye than the primeval rivers provided.

By 1902, Jordan and Evermann (1969) had defined the requirements of walleye. They prefer clear water, with rock, gravel, sand or hard clay bottom and are rarely found in muddy streams or lakes. They also prefer to inhabit water of moderate depth. The primeval Missouri River mainstem was a silt-sand bed, relatively shallow, highly turbid stream.

Cross (1967) described the sauger as common in the Missouri River and cites reports of it reaching seven pounds in early accounts. Today we find sauger most commonly associated with the turbidity near tributary confluences. The range of the native sauger is much reduced, because of dam construction which has reduced turbidity and prevented migratory movements.

The Nebraska Superintendent of Fisheries, M. E. O'Brien (1886), stated that walleye "are not generally found in the streams and ponds of the state". Walleye stocking began in earnest in 1884. They were introduced into many of our lakes and streams (eg. 16,950,000 fry were stocked in 1889, Nebraska Fish Commission Report 1889). In 1902 O'Brien appraised his 18-year walleye stocking program, "whether the walleye were more numerous before we started stocking is debatable" (Jones 1963). However, there is no question that stocking has been responsible for the presence of walleye in every river in Nebraska.

The reach of Missouri River between Fort Randall Dam and Gavins Point Dam still contains some of the features typical of the wild Missouri (ie. backwaters, chutes, sand bars and pools, islands). However, this reach no longer experiences annual flooding, the channel doesn't meander as it did, the vegetation in and along this reach is not following normal successional patterns, and sediment transport is no longer an equilibrium function.

All fish, including walleye which were introduced in large number's as the reservoirs filled in the 1950's, are declining in abundance.

Methods and Results

Nebraska and South Dakota stocked 3.7 million walleye fingerlings and 4.3 million walleye fry into the Missouri River downstream from Fort Randall Dam during the 1980's (Table 1). Many of the walleye stocked during 1980 and 1982 were marked and Nebraska attempted to recapture marked fish for several years thereafter. We also attempted to determine any strong year-class development that could be attributed to these stockings. Only a small number of marked walleye were ever recovered, and year-class strength did not correlate with the numbers stocked each year.

Experimental gillnets were most effective sampling 3-year old and older sauger and walleye in the backwaters near Niobrara (Table 2). Walleye catch per unit effort was 2.1 in 1983, 0.7 in 1984, 1.0 in 1985, and 1.0 in 1986. The higher density in the 1983 sample reflected more old fish in the sample and was not related to any stocking. We concluded in 1982 that larval walleye from Lake Francis Case were most likely the source of recruitment for this population below Fort Randall and not our stocking program (Hesse 1982). The drought and low reservoir levels in recent years would cause a reduced walleye population below Fort Randall if these observations were correct. Our most recent gillnet surveys have not collected walleye, which strenghtens our conclusion that natural reproduction upstream is important for the population in reaches adjacent to Nebraska.

Since a large number of walleye were stocked upstream from Gavins Point and none were stocked downstream, it would seem reasonable to find a higher percentage of walleye to sauger upstream than downstream if stocked fish were surviving. Actually, walleye comprised 31% of all sauger/walleye captures at Niobrara in 1983 and 33% at St. Helena. In 1984 it was 17% at Niobrara and 32% at St. Helena. Even though stocking continued at Niobrara the percentage of walleye to sauger remained nearly stable at 27% in 1985 and 26% in 1986.

South Dakota conducts annual gillnet surveys in Lewis & Clark Lake. Catch per unit effort was 1.7 in 1985, 7.7 in 1986, 3.3 in 1987, 5.0 in 1988, 3.0 in 1989 and 0.6 in 1990 (Johnson et al. 1990). Drought induced spawning problems in the large mainstream reservoirs, beginning in the mid-1980's, may be the actual cause of declining abundance in Lewis and Clark Lake and the river upstream from the lake. Moreover, when South Dakota was devising a size limit plan for their lakes and reservoirs they could find no biological justification for instituting such a limit for Lewis and Clark Lake because survival and growth was found to be better here than for any of their lakes (personal

communication: Cliff Stone, Fisheries Biologist, South Dakota Game, Fish and Parks, Chamberlain, South Dakota).

We have collected data on length of walleye (644 specimens) since 1976 for the unchannelized sections of the Missouri River between Fort Randall and Ponca, Nebraska (Table 3). The trend is to a smaller mean length which may suggest that walleye are overfished. The mean total length for the period of 1976-1982 was 410 mm; the mean length for the period of 1983-1990 was 255 mm. The difference is highly significant ($T = 9.9082$, $P = 0.001$).

Summary and Recommendation

The Missouri River ecosystem is deteriorating because of reduced turbidity, reduced flooding, no meandering, altered sediment dynamics, and changed seasonality of discharge from the dams. All native fish are in trouble and need immediate help. Walleye may or may not have been native to the Missouri, but if it was native it was never abundant and probably never will be abundant. Stocking into the Missouri River has not been effective. There may even be some negative side effects of walleye stocking. It has probably caused a dilution of the native sauger gene pool through cross breeding. We collect saugeye and continued manipulation of the relative abundance of the two species may eventually lead to the demise of the sauger.

A committe of four including: Jeff Schuckman - the District III Management Supervisor, his assistant - Scott Wessel, and the authors met to discuss the data and prepare recommendations. We recommend strong action to correct the ecosystem problems and inorder that all species will benefit including the walleye. In light of the deteriorating condition of mean length, we would suggest a reduced bag limit from six walleye/sauger to four in combination for the Missouri River including Lewis and Clark Lake, the unchannelized and channelized portions. We suggest that walleye fry and fingerling stocking into the river downstream from Fort Randall Dam should be stopped. In place of fry and fingerling stockings we recommend that 10,000 marked one-year old sauger be stocked at Niobrara and 10,000 marked sauger be stocked at St. Helena for three years on an experimental basis. We recommend a visible tag such as the disk dangler or even the Northwest Marine Technology V.I. Tag. We also recommend that the entire Missouri River along Nebraska's border should be closed to walleye and sauger harvest during the period of 1 November through 31 March each year until further notice. The purpose is to reduce fishing mortality and to prevent overharvest during the unusual circumstances of winter discharge of only 6,000 CFS.

Table 1. Walleye stocking by Nebraska and South Dakota into the Missouri and lower Niobrara Rivers during the period of 1980-1990.

Location	Year	Fry	Fingerlings
Niobrara River	1980	500,000	160,000
	1981	None	None
Missouri River	1982	None	793,000
Missouri River	1983	1,780,000	571,300
Missouri River	1984	2,000,000	555,000
Missouri River	1985	None	510,000
Missouri River	1986	None	385,000
Missouri River	1987	None	275,000
Missouri River	1988	None	215,500
	1989	None	None
Missouri River	1990	None	250,000
Totals		4,280,000	3,714,800

Table 2. Length-frequency distribution of walleye captured with experimental gillnet from backwaters of the Missouri River in 1983-1985.

	1983			1984			1985		
Size group	No.	%	Year class	No.	%	Year class	No.	%	Year class
261-280									
281-300	1	2.9		1	8.0				
301-320									
321-340	1	2.9					3	10.7	1982
341-360				1	8.0		5	17.9	1982
361-380	2	5.9	1980	1	8.0				
381-400	4	11.8	1980				2	7.1	
401-420	1	2.9		1	8.0				
421-440	2	5.9		1	8.0		2	7.1	
441-460	1	2.9					2	7.1	
461-480	4	11.8	1979	3	25.0	1980			
481-500	5	14.7	1979	3	25.0	1980	2	7.1	
501-520	1	2.9							
521-540	5	14.7	1978				6	21.4	1980
541-560	1	2.9					1	3.6	
561-580				1	8.0		1	3.6	
581-600	2	5.9					1	3.6	
601-620							1	3.6	
621-640	2	5.9							
641-660	1	2.9							
661-680	1	2.9					2	7.1	
Totals	34			12			28		

Table 3. Mean total length in millimeters (mm) and inches (in.) for walleye samples collected from the unchannelized Missouri River upstream from Lewis and Clark Lake between 1976 and 1990.

Year	No.	mm	in.
1976	2	432	17.0
1977	5	410	16.1
1980	15	487	19.2
1981	50	356	14.0
1982	55	437	17.2
1983	135	325	12.8
1984	136	202	7.9
1985	117	210	8.3
1986	72	223	8.8
1987	18	404	15.9
1988	23	346	13.6
1989	16	294	11.6
1990	17	272	10.7

Literature Cited

Cross, F.B. 1967. Handbook of fishes of Kansas. Misc. Publ. No. 45. Museum of Natural History, University of Kansas, Lawrence, KS. 357 p.

Evermann, B.W. and U.O. Cox. 1896. A report upon the fishes of the Missouri River Basin. In: House of Representatives Document No. 424, United States Commission of Fish and Fisheries, Report of the Commissioner for the year ending June 30, 1894, 325-429.

Fisher, H.J. 1945. Report on the fisheries survey of the lower Missouri River. Conservation Commission Annual Report. Jefferson City, Missouri. 81p.

Hesse, L.W. 1982. Stream fishery investigations. Final report, Dingell-Johnson Project F-55-R. Nebraska Game and Parks Commission, Norfolk, NE. 15p.

Johnson, B., D. Fielder, J. Riis, C. Stone, D. Warnick, and G. Wickstrom. 1990. Annual fish population surveys on South Dakota Missouri River Reservoirs, 1989. Progress report, Dingell-Johnson Project F-21-R, South Dakota Game, Fish and Parks, Pierre, SD. 57p.

Jones, D.J. 1963. A history of Nebraska's fishery resources. Final report, Dingell-Johnson Project F-4-R. Nebraska Game, Forestation and Parks Commission, Lincoln, NE. 76p.

Jordan, D.S. and B.W. Evermann. 1969. American Food and Game Fishes. Dover Publications, Inc. New York, NY. 574p.

Jordan, D.S. and S.E. Meek. 1885. List of fishes collected in Iowa and Missouri in August, 1884, with descriptions of three new species. Proceedings of the United States National Museum 8 (1):1-17.

Nebraska Fish Commission. 1989. The tenth annual report. State Printer. Omaha, NE. 60 pp.

O'Brien, M.E. 1886. Eighth annual report of the Fish Commission of Nebraska, 1885. Annual report, Nebraska State Board of Agriculture for the year 1885.

The effects of hydropower peaking operations at Fort Randall Dam, Missouri River, on Aufwuch macroinvertebrates downriver.

Gerald E. Mestl
Larry W. Hesse
David Oates [1]
Doug Borland [2]
Duane Fritzen [2]
David B. Marx [3]

State of Nebraska
Game and Parks Commission
Fisheries Division

Federal Aid in Fish Restoration
Dingell-Johnson Project
F-75-R-8 Job No. 1

February 1991

[1] Wildlife Division, Nebraska Game and Parks Commission, Lincoln, NE.
[2] Seasonal technicians employed by Nebraska Game and Parks Commission, Lincoln, NE.
[3] Biometry Department, University of Nebraska, Lincoln, NE.

Abstract

Fort Randall Dam is the second lowermost on the Missouri River mainstem. It is a partial hydropower peaking plant. Mean daily stage is significantly different downstream from Fort Randall Dam when compared to mean daily stage downstream from Gavins Point Dam, which is lowermost and does not peak. The objective of this study was to define the effects of these fluctuating flows on aquatic macroinvertebrate communities. There were significant differences between mean numbers of organisms colonizing substrate units when stationary devices were compared between test and control sites, but no differences when floating devices were compared between test and control sites. Colonization density was higher on substrates set deeper in the water column. We determined that deeper units were exposed to the air for less time than units nearer the water surface. Lastly, total mean density on substrate units was higher during peaking periods of lesser magnitude.

Key Words: Hydropower dams, peaking, insects, larvae, artificial substrates, colonization rates.

Introduction

There are 1,821 operating hydropower generating projects in the United States. These projects displace 4.6 million cubic feet per second (cfs) of water to annually generate 301 million megawatt hours (MWH) of electricity (Sale 1988). The displacement of water for such power generation impacts fish and wildlife spatially and temporally. Evaluation of impacts to fish and wildlife, especially in large river systems is difficult.

The Pick-Sloan Plan was a compromise legislation combining United States Bureau of Reclamation (USBR) plans with Corps of Engineers (COE) plans for hydropower development in the Missouri River Basin. Total planned Pick-Sloan Missouri Basin Project (PSMBP) generating capacity was 1,153.267 MW (Missouri Basin States Association 1985). Total actual capacity of operating Pick-Sloan generating projects was 2,742.05 MW (Missouri Basin States Association 1985). Six COE mainstem Missouri River Dams annually generate 9.5 million MWH (Corps of Engineers 1985). At all projects on the mainstem, except the lowermost (Gavins Point), hourly release rates vary widely to satisfy varying power demands (Corps of Engineers 1985). The results of releasing water diurnally to meet peak load requirements was greatly different downstream from the Fort Randall Dam (Figure 1) at the Greenwood Gage when compared with the reach of river downstream from Gavins Point Dam (Figure 2) at the Gayville, SD, Gage. The mean difference in stage (feet) between the daily high and the daily low for the period of 1 January 1984 to 1 July 1984 was 1.34 feet at the Greenwood, SD, Gage and 0.26 feet at the Gayville, SD, Gage. These means, tested by t-test were significant ($P = 0.0001$, $F = 3.57$). The effects of fluctuating discharges of this nature on the macroinvertebrates downstream from other dams have been previously investigated (Pearson and Franklin 1968, Hemsworth and Brooker 1981, Fisher and LaVoy 1972, Ward 1976). Cowell (1970) investigated the impact of water level fluctuations on plankton discharge from Missouri River reservoirs. Laflin (1981) studied flood control releases as they affect sport fisheries in a Kentucky reservoir and Walburg (1976) looked at flood control and peaking releases as they related to fish population dynamics in Lewis and Clark Lake on the Missouri River.

Figure 1. Continuous gage record at Greenwood, South Dakota, for the period of June 1983 through August 1984. Months are on the x-axis and elevation in feet on the y-axis.

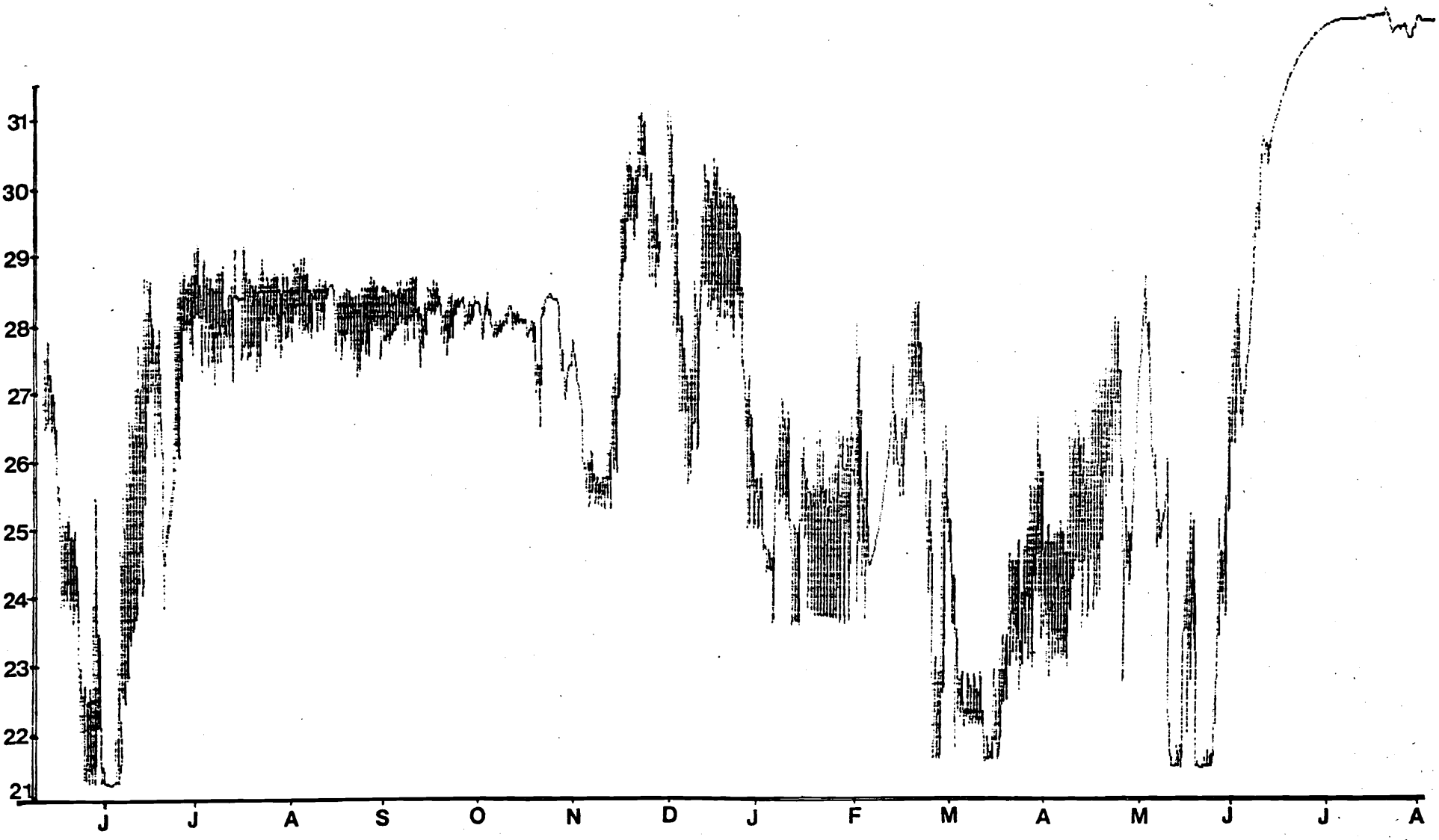
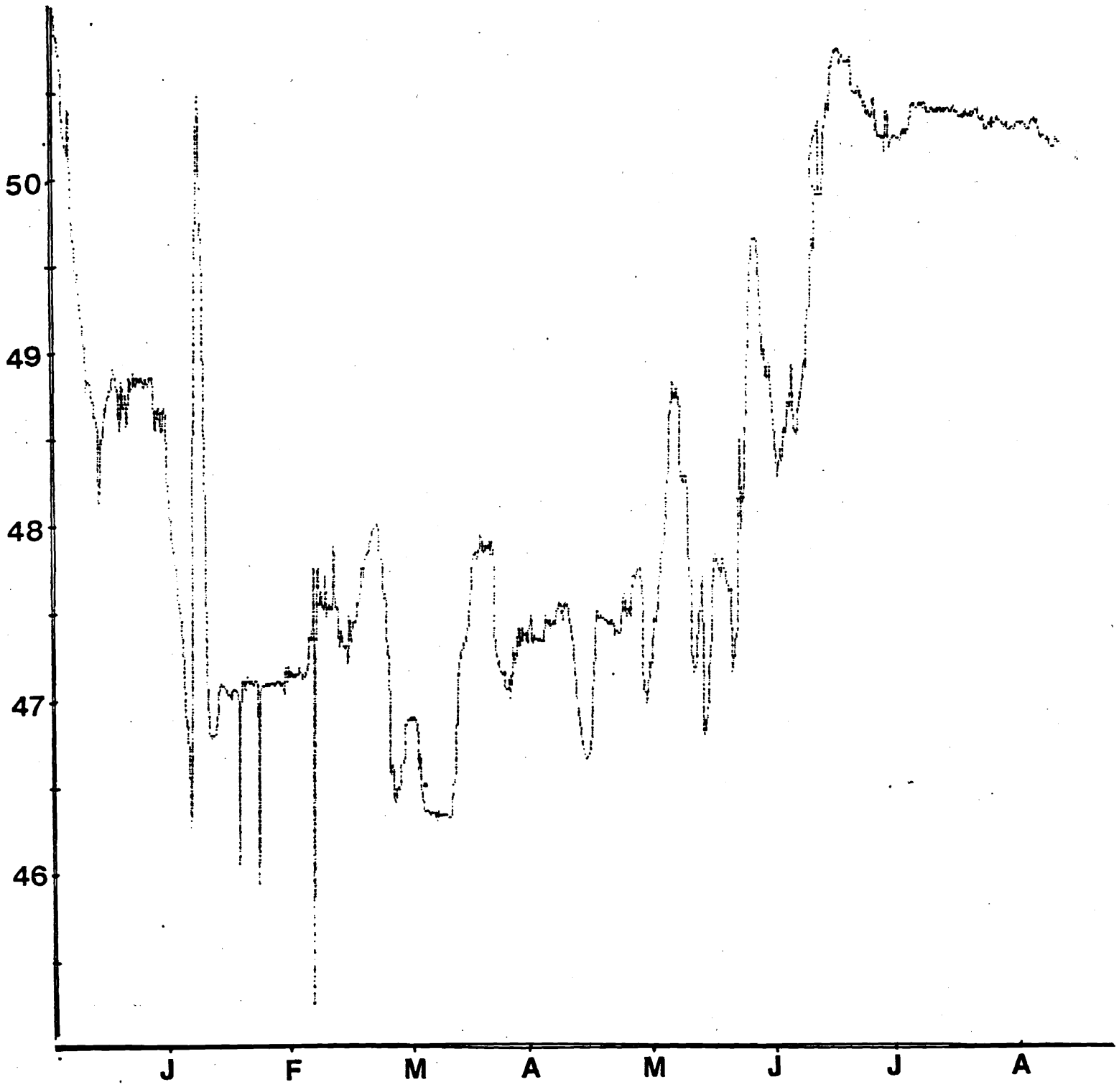

31
30
29
28
27
26
25
24
23
22
21
J
J
A
S
O
N
D
J
F
M
A
M
J
J
A

Figure 2. Continuous gage record at Gayville, South Dakota for the period of January 1984 through August 1984. Months are on the x-axis and elevation in feet are on the y-axis.


50
49
48
47
46
J
F
M
A
M
J
J
A

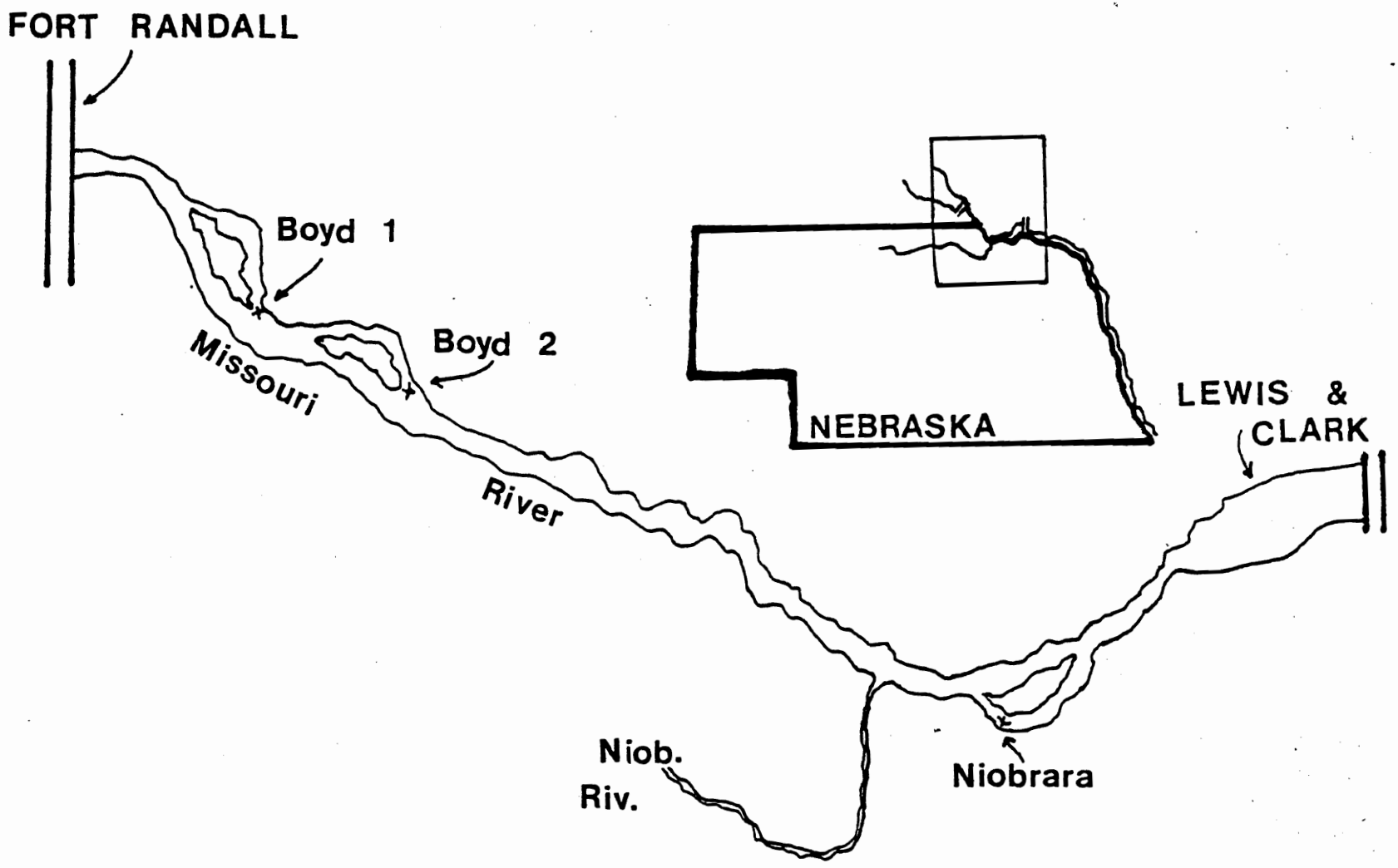
In order to evaluate the impact of peaking and flood control discharges from Fort Randall Dam on macroinvertebrate communities downstream, Hesse and Klammer (1984) conducted a pilot study during 1983. Artificial substrate samplers (Parsons and Tatum 1974) were attached to a stationary device which allowed sampling surfaces to extend through the zone of fluctuation. In addition, vertically oriented substrate units were attached to floating platforms as a control. Results of these studies were reported in Hesse and Klammer (1984). Artificial substrates in the top 38% of the water column averaged 2,178 larvae per m^2 compared to 4,252 larvae per m^2 on units deeper in the column where they were subjected to less frequent fluctuations (Table 15, Hesse and Klammer 1984). It was decided from these data to conduct a more detailed investigation.

The objective of this study was to define the effect of fluctuating discharge from Fort Randall Dam due to hydropower peaking releases. We were interested in how these unnatural water releases altered species composition and relative abundance, and the density of aquatic macroinvertebrates on attachment substrates.

Methods

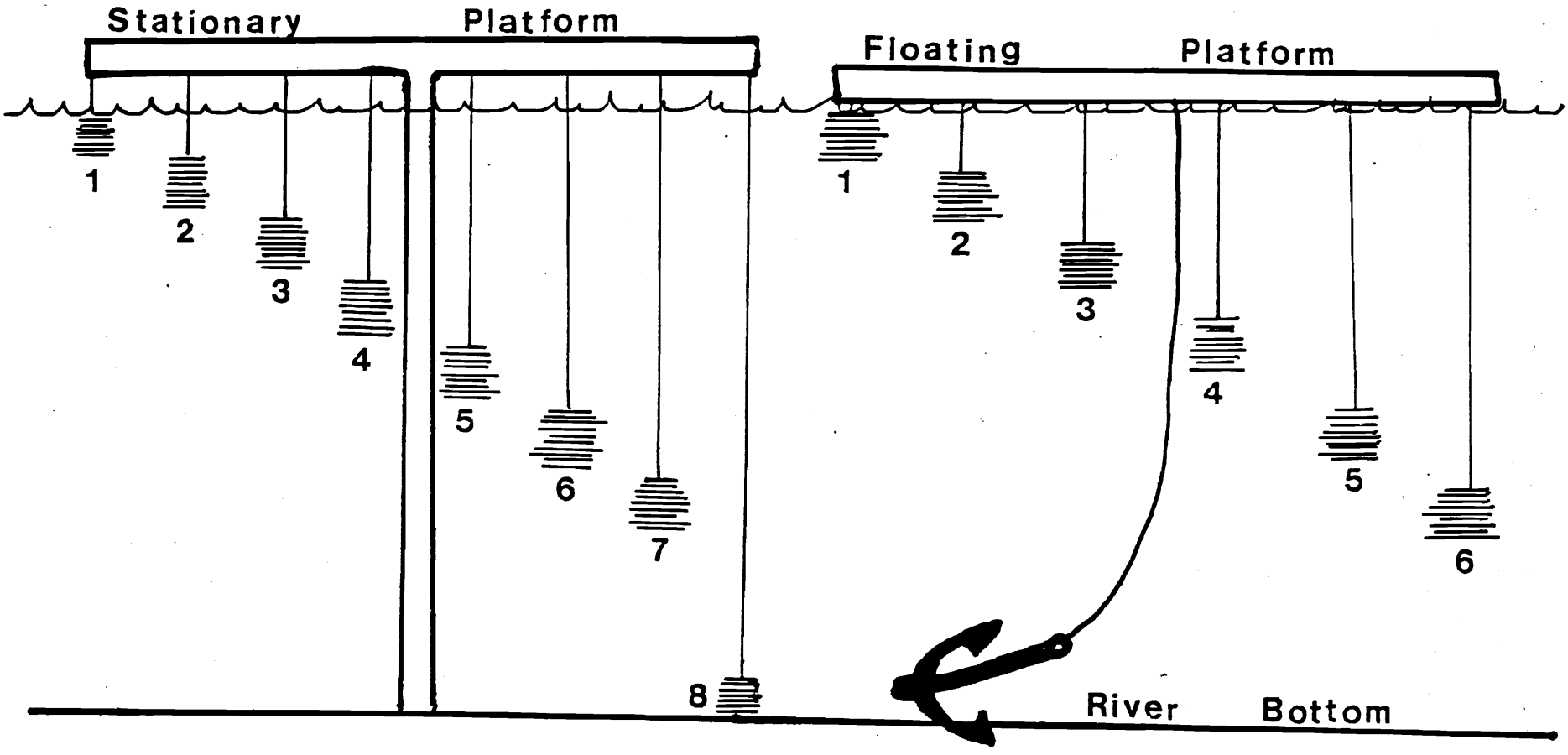
It was hypothesized that because the affects of peaking dissipate downriver the greatest impact from water level fluctuations would occur nearer to Fort Randall Dam located at river mile (RM) 880. Two test sites were established in areas off from the main channel at RM 870.2 (Boyd 1) and 867.2 (Boyd 2)(Figure 3). A control site was established downstream at RM 838.5 (Niobrara). This site was 7.24 km upstream from the head end of Lewis and Clark Lake. We tested, by regression analyses, diurnal differences between daily maximum and minimum stage at Greenwood which is just 1 km downstream from the test sites, and Niobrara and found they were not related. This resulted from the fact that the Niobrara site was 67 km downstream from Fort Randall Dam, the Niobrara River dumps in just upstream from the site and there may be some impoundment effects reaching this site from Lewis and Clark Lake.

Figure 3. Map of the study area, Fort Randall Dam in South Dakota to Lewis and Clark Lake in Nebraska.


FORT RANDALL
Boyd 1
Boyd 2
Missouri
River
NEBRASKA
LEWIS &
CLARK
Niob.
Riv.
Niobrara

Two types of platforms were used to hold artificial substrate sampler units (Figure 4). The floating platform served as a control at test and control sites. Artificial substrates units were composed of 10 hardboard plates, 8 cm in diameter mounted on a bolt separated by flat washers to provide different clearances and different habitat. The entire unit was 8 cm deep, provided 9.29 cm^2 (1 ft^2) of colonization substrate. The floating platforms, which moved up and down with the fluctuating water levels, always maintained substrate units in the water. Six substrate units were attached to the floating platforms from the water surface at 8 cm intervals. The number one substrate unit on stationary platforms was set at an elevation equivilant to what appeared to be the high water mark. Six more were set at 8 cm intervals and unit 8 was set just above the bottom. Water levels fluctuated up and down diurnally, which alternately inundated and exposed some of these units.

Figure 4. Platform and substrate unit configuration used during peaking studies on the Missouri River, Nebraska.


Stationary Platform
Floating Platform
1
2
3
4
5
6
7
8
1
2
3
4
5
6
River Bottom

At each of the three collection sites, 2 stationary and 2 floating platforms with a total of 28 substrate units were placed in the river and recovered every three weeks during the open water period from 1986 through 1988, except for the first sampling period in 1986 during which fewer units were placed in the river. In total, 1,476 substrate units were placed out.

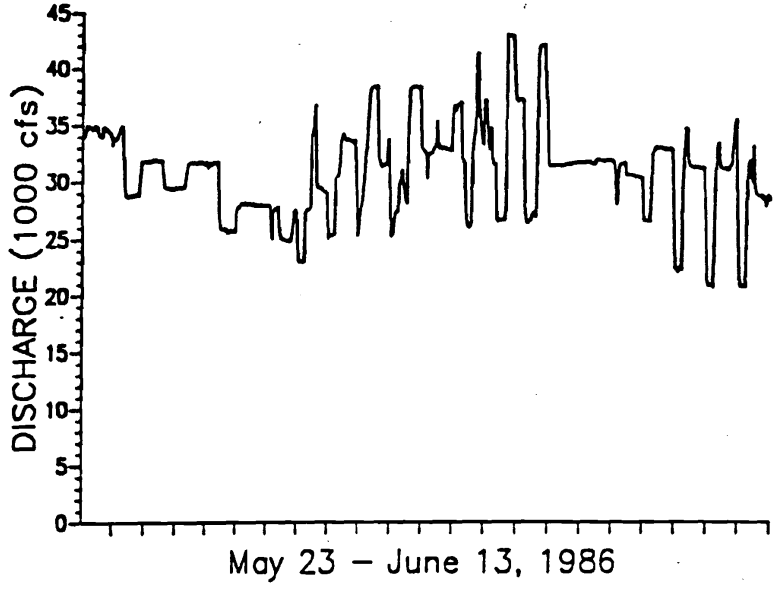
Hourly discharge from Fort Randall Dam was obtained from the COE for the study period. In addition, gage data (stage in feet above MSL) were acquired from gages at Greenwood, SD, Running Water, SD, near Niobrara and Gayville, SD. These data were collected by the United States Geologic Survey (USGS).

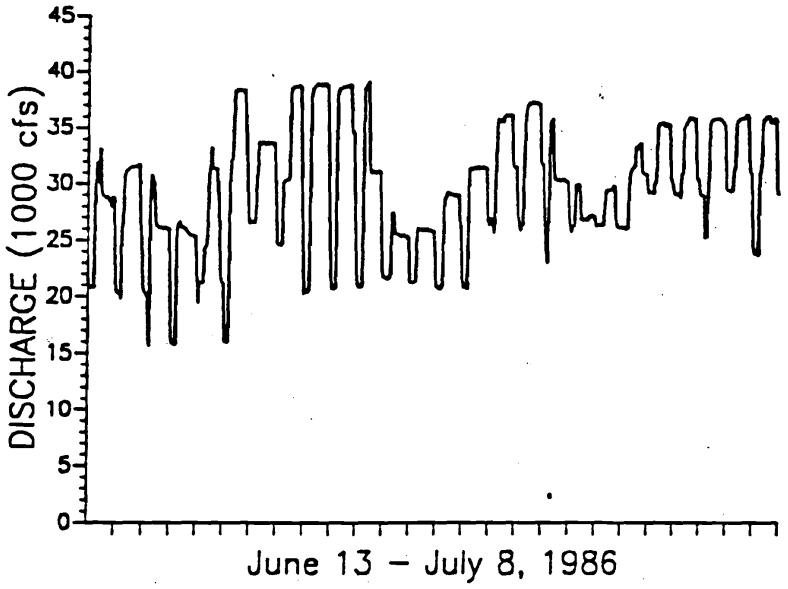
Entire substrate units were carefully removed from the platforms and returned to the laboratory in pint containers preserved with 10% buffered formalin. In the laboratory, samplers were disassembled and flushed into assorted size screens 16 (1.18 mm), 35 (0.5 mm), and 80 (0.18 mm) to effectively remove excess detritus without losing macroinvertebrates. Most Invertebrates were collected on the 0.5 mm sieve. Invertebrates were flushed into a white bowl, excessive water was removed with a 30 ml syringe and 16 gauge needle. Needles were covered with a 0.25 mm mesh sleeve to prevent loss of small instars. Samples were stored in 20 ml vials containing 70% ethanol for identification and enumeration.

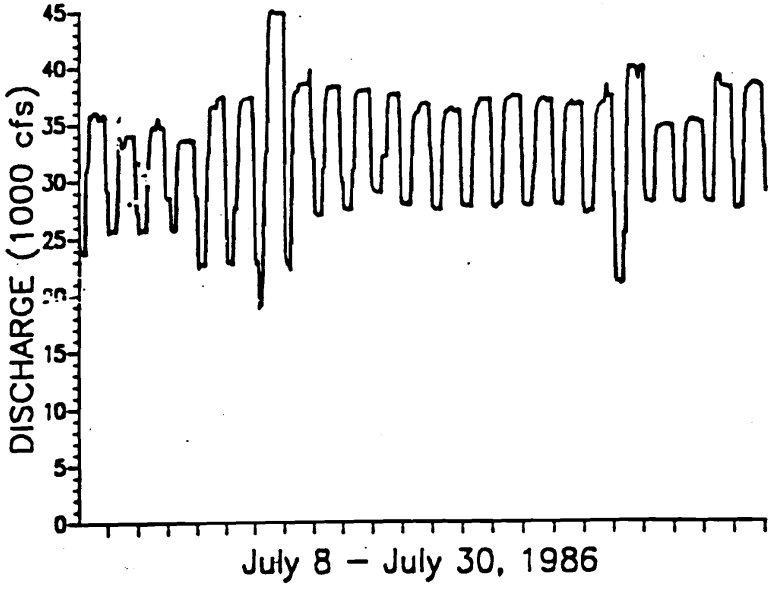
Results

Hourly discharge (cfs) information for Fort Randall Dam was obtained from the COE and plotted for each sample period (Figure 5). The standard deviation of the mean daily discharge ranged from 4,100 to 10,080 for individual sample periods indicating widely fluctuating water levels. Regression models were developed between discharge from Fort Randall Dam and river stage at each gaging station. There was a highly significant relationship (stage=0.1937xdischarge) between discharge from Fort Randall Dam and the stage at the Greenwood Gage seven hours later ($P = 0.0001$, $r = 0.9085$). There was an increase of 0.97 feet in river stage for every 5000 cfs of water released from Fort Randall Dam. A regression model which would relate discharge from Fort Randall Dam with timed changes in stage at the Running Water gage could not be developed due to incremental increases in volume. The stage information from Greenwood reflected the fluctuating discharge from Fort Randall Dam (Table 1). Stage fluctuated from 2.77 to 8.71 feet during the three week sampling periods (Table 2).

Figure 5. Hourly discharge from Fort Randall Dam for 18 sample periods between May 1986 and October 1988.


DISCHARGE (1000 cfs)
0
5
10
15
20
25
30
35
40
45
May 23 – June 13, 1986


DISCHARGE (1000 cfs)
0
5
10
15
20
25
30
35
40
45
June 13 – July 8, 1986


DISCHARGE (1000 cfs)
0
5
10
15
20
25
30
35
40
45
July 8 – July 30, 1986

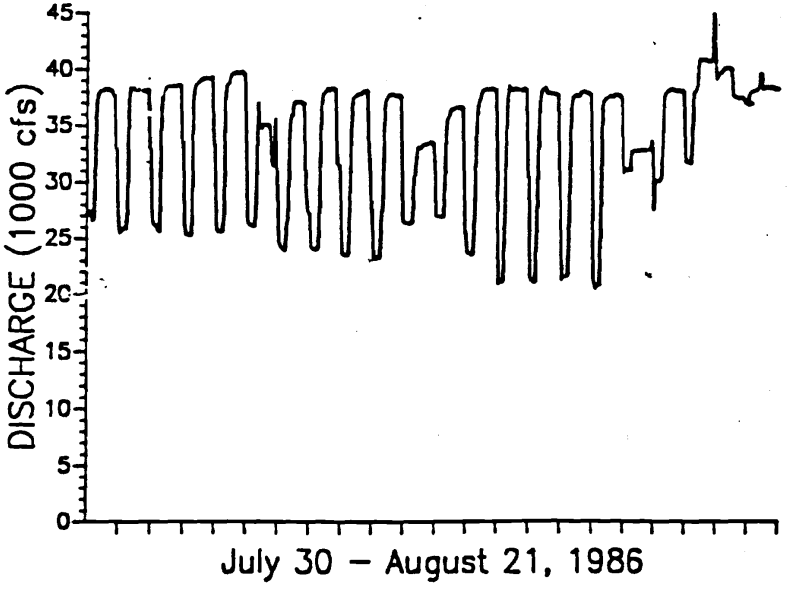
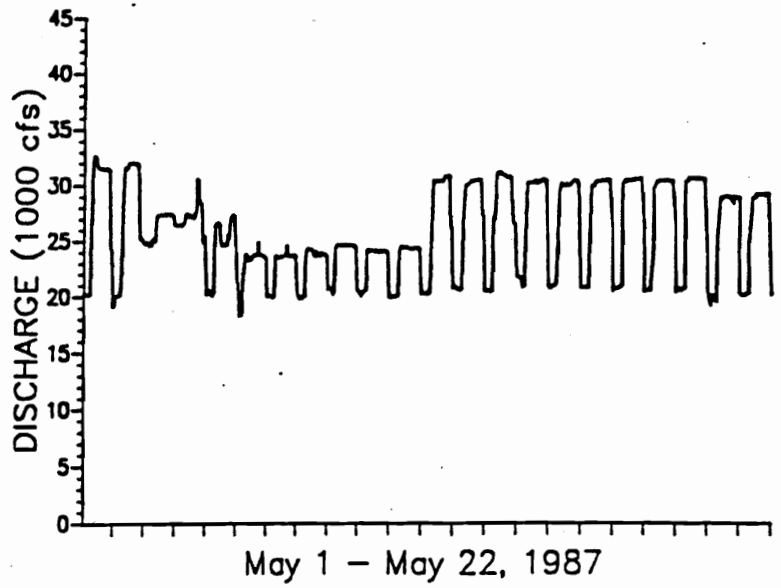
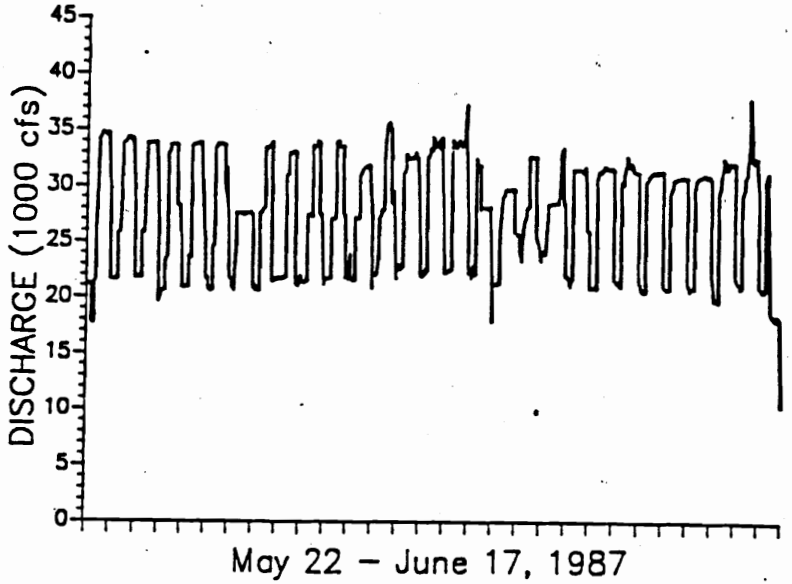

DISCHARGE (1000 cfs)
0
5
10
15
20
25
30
35
40
45
July 30 – August 21, 1986

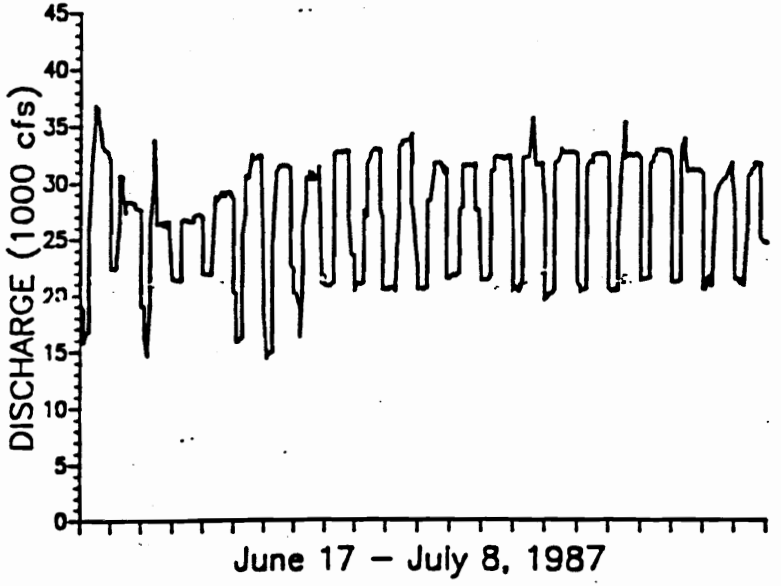
Figure 5 Continued. Hourly discharge from Fort Randall Dam for 18 sample periods between May 1986 and October 1988.



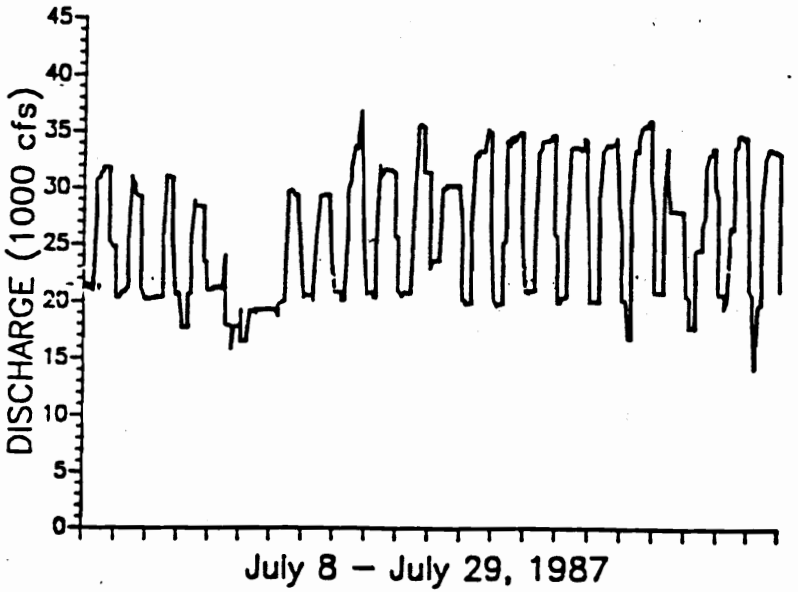
May 1 – May 22, 1987



May 22 – June 17, 1987

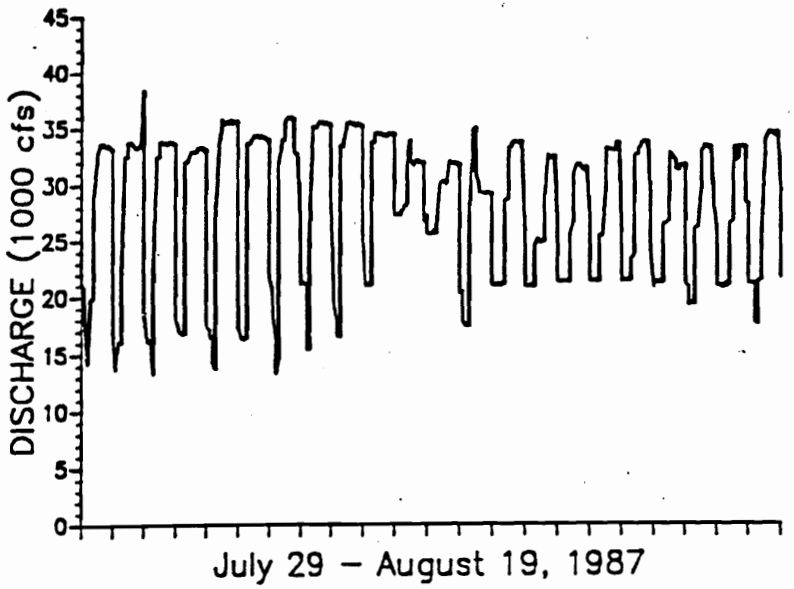


June 17 – July 8, 1987

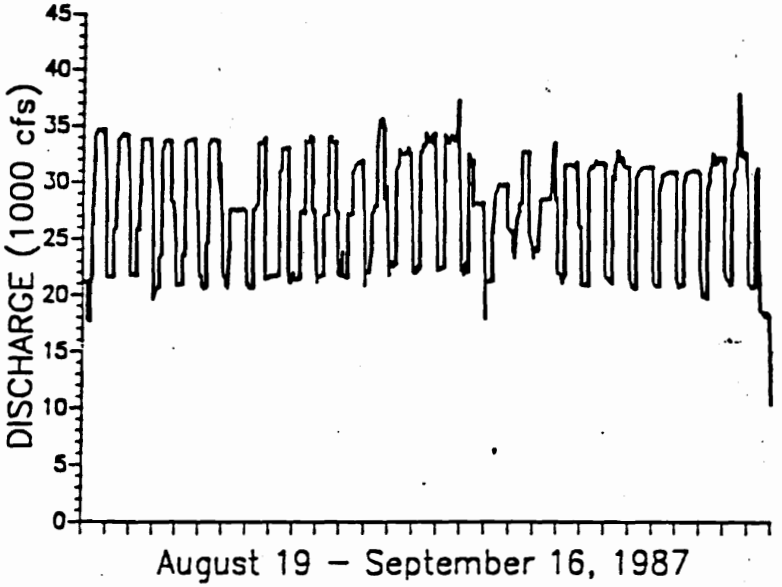


July 8 – July 29, 1987

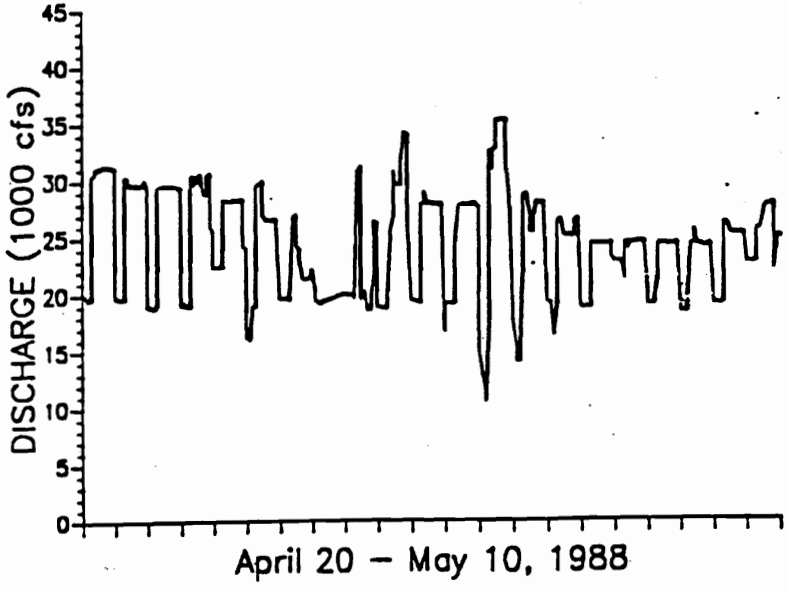
Figure 5 Continued. Hourly discharge from Fort Randall Dam for 18 sample periods between May 1986 and October 1988.



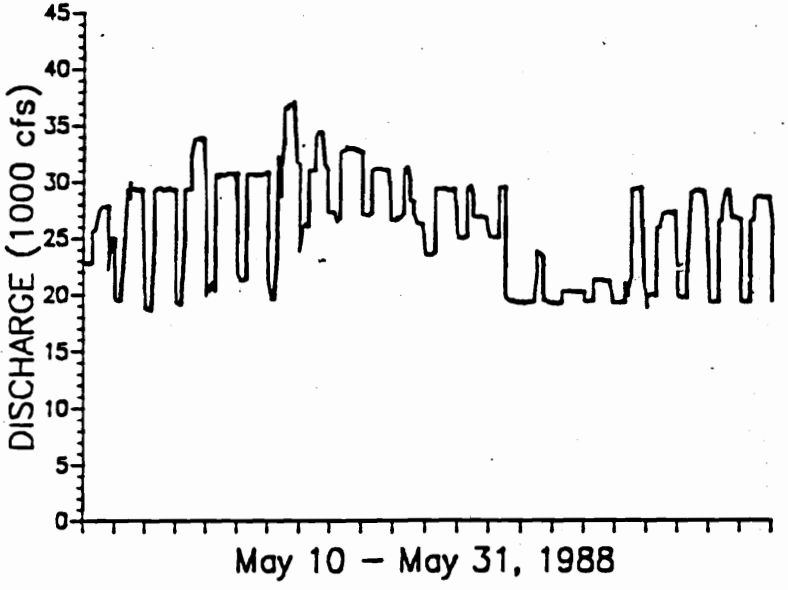
July 29 – August 19, 1987



August 19 – September 16, 1987

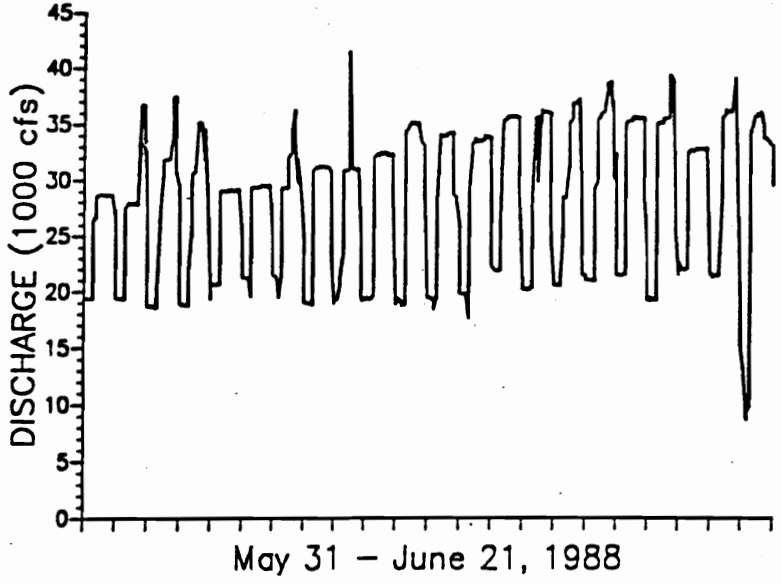


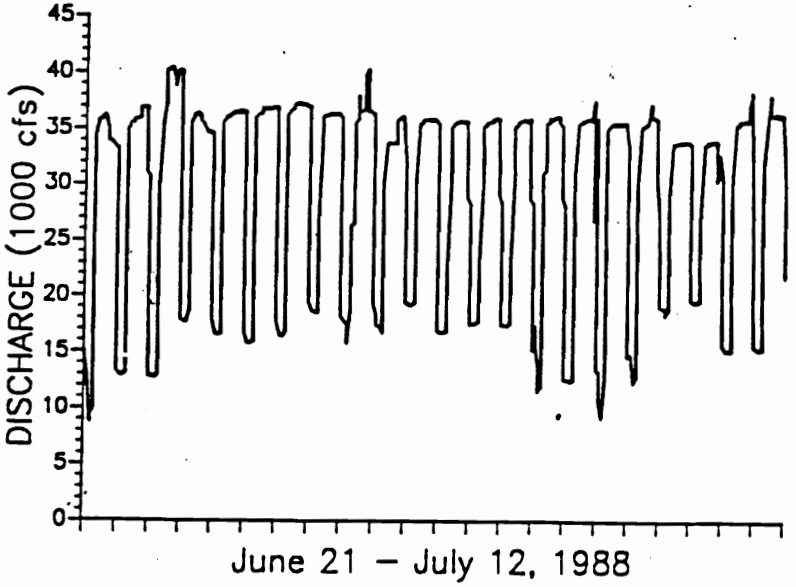
April 20 – May 10, 1988

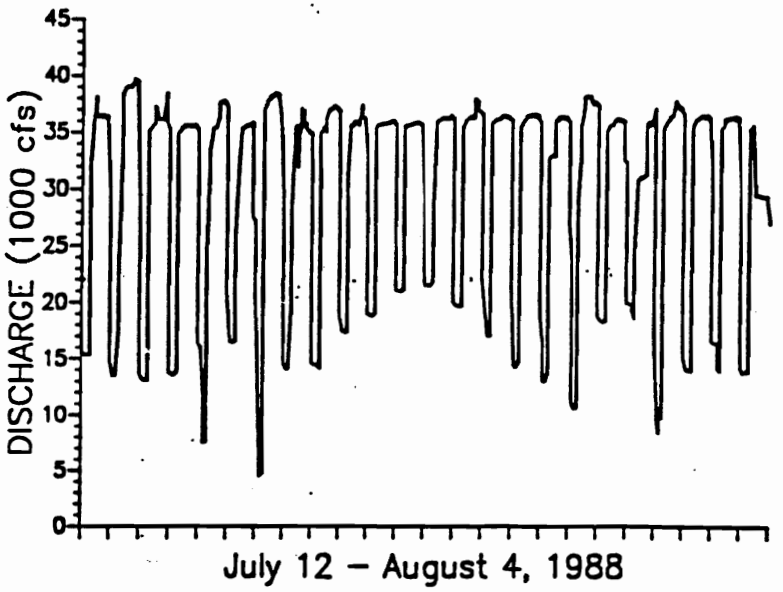


May 10 – May 31, 1988

Figure 5 Continued. Hourly discharge from Fort Randall Dam for 18 sample periods between May 1986 and October 1988.


DISCHARGE (1000 cfs)
0
5
10
15
20
25
30
35
40
45
May 31 – June 21, 1988


DISCHARGE (1000 cfs)
0
5
10
15
20
25
30
35
40
45
June 21 – July 12, 1988


DISCHARGE (1000 cfs)
0
5
10
15
20
25
30
35
40
45
July 12 – August 4, 1988

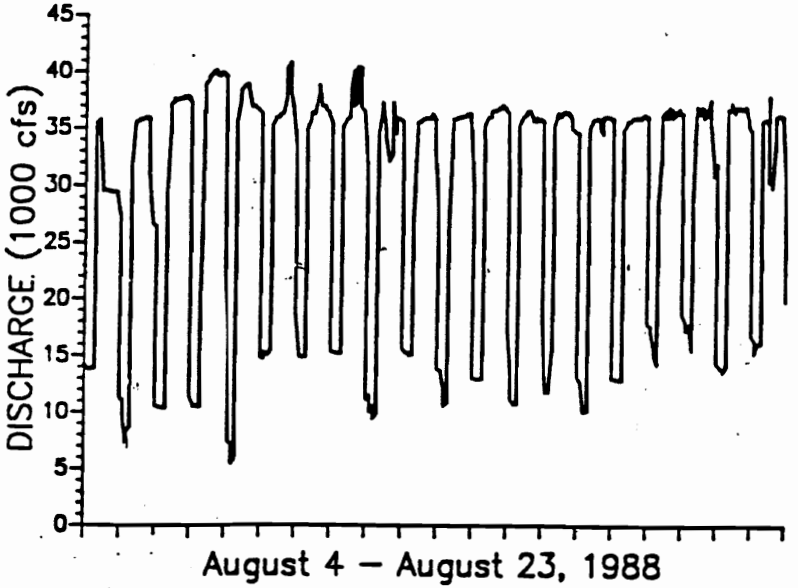
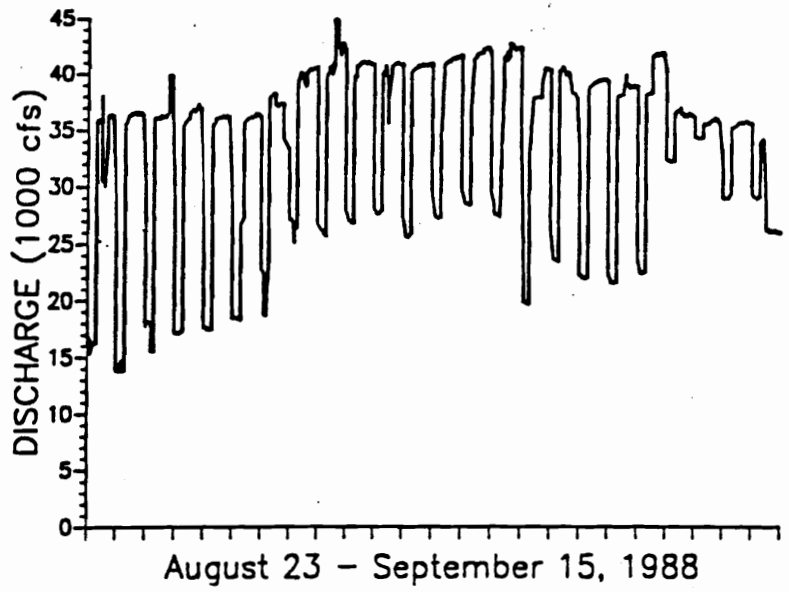

DISCHARGE (1000 cfs)
0
5
10
15
20
25
30
35
40
45
August 4 – August 23, 1988

Figure 5 Continued. Hourly discharge from Fort Randall Dam for 18 sample periods between May 1986 and October 1988.


DISCHARGE (1000 cfs)
45
40
35
30
25
20
15
10
5
0
August 23 – September 15, 1988

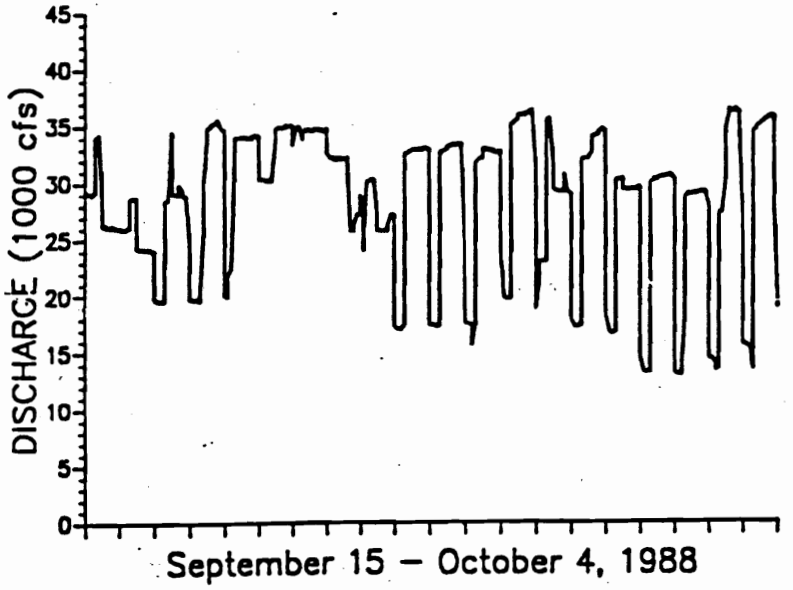

DISCHARGE (1000 cfs)
45
40
35
30
25
20
15
10
5
0
September 15 – October 4, 1988

Table 1. Minimum, maximum, mean and standard deviation of the mean for discharge (x 1,000 cfs) from Fort Randall Dam for 3 week sample periods.

	Discharge				Difference
Sample	Min	Max	Mean	Std	Min-Max
June 13, 1986	20.72	42.99	30.78	4.10	22
July 8, 1986	15.74	39.05	29.39	5.52	23
July 30, 1986	18.77	44.97	32.72	5.36	26
August 21, 1986	20.45	44.82	33.79	5.68	25
May 22, 1987	18.21	32.53	25.58	4.05	15
June 17, 1987	0.00	37.68	24.05	7.54	38
July 8, 1987	14.34	36.71	27.12	5.31	23
July 29, 1987	14.21	36.77	25.96	5.99	23
August 19, 1987	13.30	38.33	28.25	6.36	25
September 16, 1987	10.42	37.82	27.54	5.13	27
May 10, 1988	10.57	35.24	24.46	4.63	24
May 31, 1988	18.61	37.03	25.98	4.80	18
June 21, 1988	8.71	41.32	28.18	6.55	32
July 12, 1988	8.71	40.31	29.46	8.76	31
August 4, 1988	4.51	39.64	29.80	8.93	35
August 23, 1988	5.51	40.92	29.26	10.08	35
September 15, 1988	13.71	44.72	33.95	7.35	31
October 4, 1988	12.94	36.46	28.58	6.25	23
All	0.00	44.97	28.61	7.05	

Table 2. Minimum, maximum, mean and standard deviation of the mean for stage (feet above MSL) at Greenwood, South Dakota, for 3 week sample periods.

	Discharge				Difference
Sample	Min	Max	Mean	Std	Min-Max
June 13, 1986	4.01	8.33	5.96	0.79	4
July 8, 1986	3.05	7.56	5.69	1.07	5
July 30, 1986	3.63	8.71	6.34	1.04	5
August 21, 1986	3.96	8.68	6.54	1.10	5
May 22, 1987	3.53	6.30	4.96	0.79	3
June 17, 1987	0.00	7.30	4.66	1.46	7
July 8, 1987	2.78	7.11	5.25	1.03	4
July 29, 1987	2.75	7.12	5.03	1.16	4
August 19, 1987	2.58	7.42	5.47	1.23	5
September 16, 1987	2.02	7.33	5.34	0.99	5
May 10, 1988	2.05	6.83	4.74	0.90	5
May 31, 1988	3.60	7.17	5.03	0.93	4
June 21, 1988	1.69	8.00	5.46	1.27	6
July 12, 1988	1.69	7.81	5.71	1.70	6
August 4, 1988	0.87	7.68	5.77	1.73	7
August 23, 1988	1.07	7.93	5.67	1.95	7
September 15, 1988	2.66	8.66	6.58	1.42	6
October 4, 1988	2.51	7.06	5.54	1.21	5
All	0.00	8.71	5.54	1.36	

The stationary platforms had eight substrate units located within the fluctuation zone. However, since each substrate unit was only 8 cm deep and there were only seven effective units (the eighth could not be compared because of the variable distance from the seventh unit), only the top 55 cm of the fluctuation zone was studied. Table 2 shows that during any three-week period the least difference between the minimum and maximum stage was 85 cm. None of the effective stationary platform units remained in the water throughout the three-week periods. The fluctuation zone, in fact, was very large (up to 213 cm).

Eighteen three-week time periods were sampled from 1986 through 1988. Approximately 275,000 organisms were identified, representing 104 different genera, families and orders (Table 3). Three groups made up 82% of the organisms collected: Chironomidae-56%, Oligochaeta- 19% and Caenis sp. - 7%. Many organisms could be described as rare with fewer than 25 individuals collected from 70 of the 104 groups. The mean number of organisms per substrate unit was 2.8 times greater at Niobrara on stationary platforms and 1.9 times greater on floating platforms (Table 4). Tables 5, 6 and 7 present the mean number of the three dominant groups per substrate unit.

Table 3. Total number of each organism collected by size and method.

Taxon	Boyd County 1		Boyd County 2		Niobrara	
	stat.	float	stat.	float	stat.	float
Hexagenia larvae	2	1	0	1	15	0
Caenis larvae	1263	1737	1723	2356	5573	6815
Brachycercus larvae	0	0	0	0	1	0
Heptageniidae larvae	0	5	0	0	0	0
Heptagenia larvae	0	0	1	0	4	1
Stenonema larvae	4	3	15	0	7	9
Paraleptophlebia larvae	2	0	0	0	0	0
Baetis larvae	68	26	36	25	8	10
Centroptilum larvae	1	0	1	0	0	0
Callibaetis larvae	0	0	0	0	0	1
Baetisca larvae	0	3	0	0	0	1
Ephemerella larvae	0	0	0	0	0	1
Trichoptera larvae	0	1	0	1	1	0
Trichoptera pupae	1	0	5	0	0	0
Trichoptera adult	1	0	0	0	0	0
Hydropsyche larvae	2	0	0	0	0	0
Hydropsyche pupae	0	0	0	1	0	1
Potamyia larvae	1	0	0	0	1	0
Polycentropodidae larvae	1	0	0	0	0	0
Neuroclipsis larvae	5	11	6	5	41	38
Cyrnellus larvae	0	1	0	1	1	4

Table 3 Continued. Total number of each organism collected by size and method.

Taxon	Boyd County 1 stat.	Boyd County 1 float	Boyd County 2 stat.	Boyd County 2 float	Niobrara stat.	Niobrara float
Polycentropus larvae	4	15	2	3	20	15
Hydroptilidae larvae	0	0	0	0	3	0
Mayatrichia larvae	0	0	0	0	0	1
Hydroptila larvae	300	448	72	92	274	420
Hydroptila pupae	0	1	2	0	0	0
Agraylea larvae	38	14	84	146	35	16
Ochrotrichia larvae	3	7	4	3	132	106
Leptoceridae larvae	0	0	2	0	0	0
Leptoceridae pupae	0	1	0	0	0	0
Ceraclea larvae	0	0	0	0	1	0
Ceraclea pupae	0	0	1	0	0	0
Nectopsyche larvae	28	43	13	9	3	2
Nectopsyche pupae	0	0	1	0	0	0
Oecetis larvae	18	31	32	61	27	42
Leptocerus larvae	0	0	1	1	1	1
Limnephilidae larvae	1	0	0	0	0	8
Limnephilidae pupae	0	1	0	0	0	0
Pycnopsyche larvae	0	2	0	0	0	0
Philiopotamidae larvae	1	0	0	0	0	0
Brachycentrus larvae	1	1	0	0	0	0

Table 3 Continued. Total number of each organism collected by size and method.

Taxon	Boyd County 1		Boyd County 2		Niobrara	
	stat.	float	stat.	float	stat.	float
Psychomyiidae larvae	0	6	0	119	0	1
Diptera adult	0	0	0	0	0	1
Chironomidae larvae	18821	25134	11989	17151	42413	39304
Chironomidae pupae	675	637	420	545	352	325
Chironomidae adult	13	3	5	1	0	4
Pseudosmittia larvae	0	0	0	0	8	8
Chaobordiae larvae	0	3	0	0	2	0
Chaobordiae pupae	0	8	1	0	2	0
Simuliidae larvae	0	0	0	0	1	0
Heleidae larvae	64	23	54	54	682	494
Empididae larvae	0	1	0	0	2	0
Perlidae larvae	1	0	0	0	0	2
Acrioneuria larvae	0	0	0	0	0	1
Perlodidae larvae	0	0	0	0	1	0
Isoperla larvae	37	72	3	2	6	10
Perlinella larvae	0	0	0	0	1	0
Perlesta larvae	0	0	1	0	3	1
Odonata larvae	0	0	0	4	8	3
Coenagrionidae	4	3	12	10	58	12
Agria larvae	13	15	22	23	147	184

Table 3 Continued. Total number of each organism collected by size and method.

Taxon	Boyd County 1		Boyd County 2		Niobrara	
	stat.	float	stat.	float	stat.	float
Ischnura larvae	5	5	5	8	18	35
Coenagrio larvae	1	0	14	0	6	1
Enallagma larvae	41	47	62	108	110	202
Gomphidae larvae	0	1	0	0	2	0
Gomphus larvae	1	3	0	0	1	0
Libellulidae larvae	0	0	0	1	2	1
Lestidae larvae	7	0	1	0	0	0
Lestes larvae	6	0	6	1	0	0
Aeshinidae larvae	1	0	0	0	0	0
Coleoptera larvae	1	0	0	0	2	0
Halipidae larvae	0	11	0	0	0	0
Halipidae adult	0	0	1	0	0	0
Dytiscidae larvae	1	0	0	2	2	5
Gyrinidae larvae	171	240	120	142	564	420
Hydrophilidae larvae	4	1	0	0	0	6
Hydrophilidae adult	0	0	0	1	0	0
Elmidae larvae	0	0	0	1	0	0
Elmidae adult	0	0	0	0	1	4
Carabidae larvae	0	0	1	0	0	0
Noteridae	0	1	0	0	0	49

Table 3 Continued. Total number of each organism collected by size and method.

Taxon	Boyd County 1		Boyd County 2		Niobrara	
	stat.	float	stat.	float	stat.	float
Corixidae	0	2	1	1	6	1
Naucoridae	0	0	0	0	0	5
Pleidae	1	0	0	0	0	0
Lepidoptera pupae	2	0	0	0	0	0
Hymenoptera pupae	0	0	1	0	0	0
Hymenoptera adult	2	2	1	3	2	0
Formicidae adult	0	0	0	0	1	0
Corydalus larvae	1	0	0	0	0	0
Thysanoptera	2	0	0	1	0	0
Arachnoida	0	0	2	0	0	0
Hydarcarnia	14	31	19	11	16	39
Araneida	127	140	32	223	31	7
Crustacea	0	0	0	0	1030	0
Asellus	0	0	0	0	65	1
Amphipoda	2	6	2	6	11	4
Hyalella	6	6	3	7	24	102
Oligochaeta	6280	9458	3332	5384	12539	14070
Nematoda	41	75	13	25	35	14

Table 3 Continued. Total number of each organism collected by size and method.

	Boyd County 1		Boyd County 2		Niobrara	
Taxon	stat.	float	stat.	float	stat.	float
Hirudinea	0	0	2	4	8	7
Pelecypoda	16	2	13	16	39	47
Gastropoda	5	3	3	29	77	43
Ostrocoda	1221	2117	2547	3185	7309	7192
Unidentified zooplankton	736	138	2544	2199	5130	1575
All	30068	40546	23233	31972	76856	71672

Table 4. Mean number of all organisms combined per substrate unit.

Unit	Site 1 Stationary	Site 2 Stationary	Site 3 Stationary
1	40.4	17.1	152.2
2	50.4	22.4	256.7
3	80.6	54.1	319.3
4	75.4	78.9	332.6
5	131.9	84.4	324.3
6	159.4	130.0	379.8
7	150.0	144.9	325.5
8	197.9	190.0	222.0

Unit	Site 1 Floating	Site 2 Floating	Site 3 Floating
1	187.6	146.3	327.8
2	223.4	187.5	370.2
3	194.6	209.5	382.9
4	177.5	164.8	417.0
5	224.4	164.1	314.3
6	205.7	198.9	299.8

Table 5. Mean number of Chironomidae per substrate unit.

Unit	Site 1 Stationary	Site 2 Stationary	Site 3 Stationary
1	17.1	9.0	81.2
2	29.4	11.8	139.3
3	44.1	21.6	159.2
4	48.1	32.7	188.7
5	75.7	48.7	172.1
6	99.9	68.3	221.9
7	97.2	75.6	187.1
8	135.0	103.0	113.9

Unit	Site 1 Floating	Site 2 Floating	Site 3 Floating
1	100.4	67.1	137.7
2	126.7	109.0	216.7
3	134.5	98.9	194.2
4	121.9	90.1	238.7
5	145.4	100.7	192.8
6	122.3	108.4	174.7

Table 6. Mean number of Oligocheata per substrate unit.

Unit	Site 1 Stationary	Site 2 Stationary	Site 3 Stationary
1	17.8	1.8	28.7
2	12.4	2.6	52.2
3	27.1	3.8	52.8
4	14.8	8.5	49.8
5	28.7	12.6	45.4
6	26.0	14.7	62.7
7	27.1	27.0	43.1
8	31.4	31.5	41.9

Unit	Site 1 Floating	Site 2 Floating	Site 3 Floating
1	49.0	30.4	118.3
2	35.5	32.5	69.7
3	26.8	25.8	70.2
4	26.0	30.3	45.1
5	51.6	23.2	52.1
6	42.7	30.3	53.0

Table 7. Mean number of *Caenis sp.* per substrate unit.

Unit	Site 1 Stationary	Site 2 Stationary	Site 3 Stationary
1	1.5	2.4	14.7
2	2.5	2.7	21.9
3	3.2	5.1	22.2
4	3.7	7.1	18.2
5	7.1	7.8	26.8
6	5.5	10.2	24.1
7	5.6	7.1	19.4
8	6.6	10.8	21.9

Unit	Site 1 Floating	Site 2 Floating	Site 3 Floating
1	7.5	20.5	25.5
2	6.8	9.5	32.6
3	7.2	12.4	38.9
4	7.2	12.8	38.5
5	6.4	12.2	33.5
6	10.1	11.3	34.0

To test the hypothesis that floating platforms were actually acting as a control we looked at the differences between the square root transformations of the mean number of organisms per sampling unit at site 3. Only Caenis sp. had any significant difference (Table 8). We then tested the floating and stationary platforms at sites 1 and 2 combined. The mean number of total organisms and the three major groups were all significantly different (Table 8).

Table 8. T-tests comparing the square root transformation of the mean number of organisms per sampling unit between stationary and floating platforms. S denotes significant difference (P = 0.05). NS means no significant difference.

	Site 3	Sites 1 and 2 combined			
	All Units	All Units	All float vs stat. 7	All float vs stat. 6-7	All float vs stat. 5-7	All float vs stat. 4-7
Total Organisms	NS	S	S	S	S	S
Caenis sp.	S	S	NS	NS	NS	S
Chironomidae	NS	S	NS	S	S	S
Oligochaetes	NS	S	NS	NS	S	S

We then tested to see if there was a difference in the mean number of organisms collected by method between sites. For total organisms and for the three dominant groups there was a very large and statistically significant (t-test, p=0.05) difference between the density on substrate units on floating platforms when sites 1 and 2 were compared to site 3, and no significant difference between sites 1 and 2. This supports our use of site 3 as a peaking control site. Since this observation applies to stationary units as well, we believe that some factor (probably peaking) has reduced the standing crop of insects in Boyd County, but we will discuss this in greater detail later.

Floating platforms were used to obtain information about any insect behavioral adaptation for depth. Figure 6 shows there are more total insects at mid-depth. The data are presented as a square root transformation of the mean number of insects per substrate unit plotted for each depth (unit 1 is near the surface, unit 6 is 48 cm below the surface). Total insects reacted to depth in the same way at all three sites (Figure 6). Total insects and chironomidae had statistically similar quadradic lines differing only in their intercept. Sites 1 and 2 differ significantly from site 3 but not from each other. Caenis sp. had a quadradic response, although each line was significantly different. Oligochaeta had a linear response to depth at site 3 where the slope was negative. The depth response was masked by peaking in sites 1 and 2. There was no slope associated with these linear relationships. Plotted data show the overall higher density at Niobrara which supports our contention that standing crop is reduced in Boyd County.

Figure 6. Plots of regression analyses of squate root transformed mean density of invertebrates on units at different depths from floating platforms.

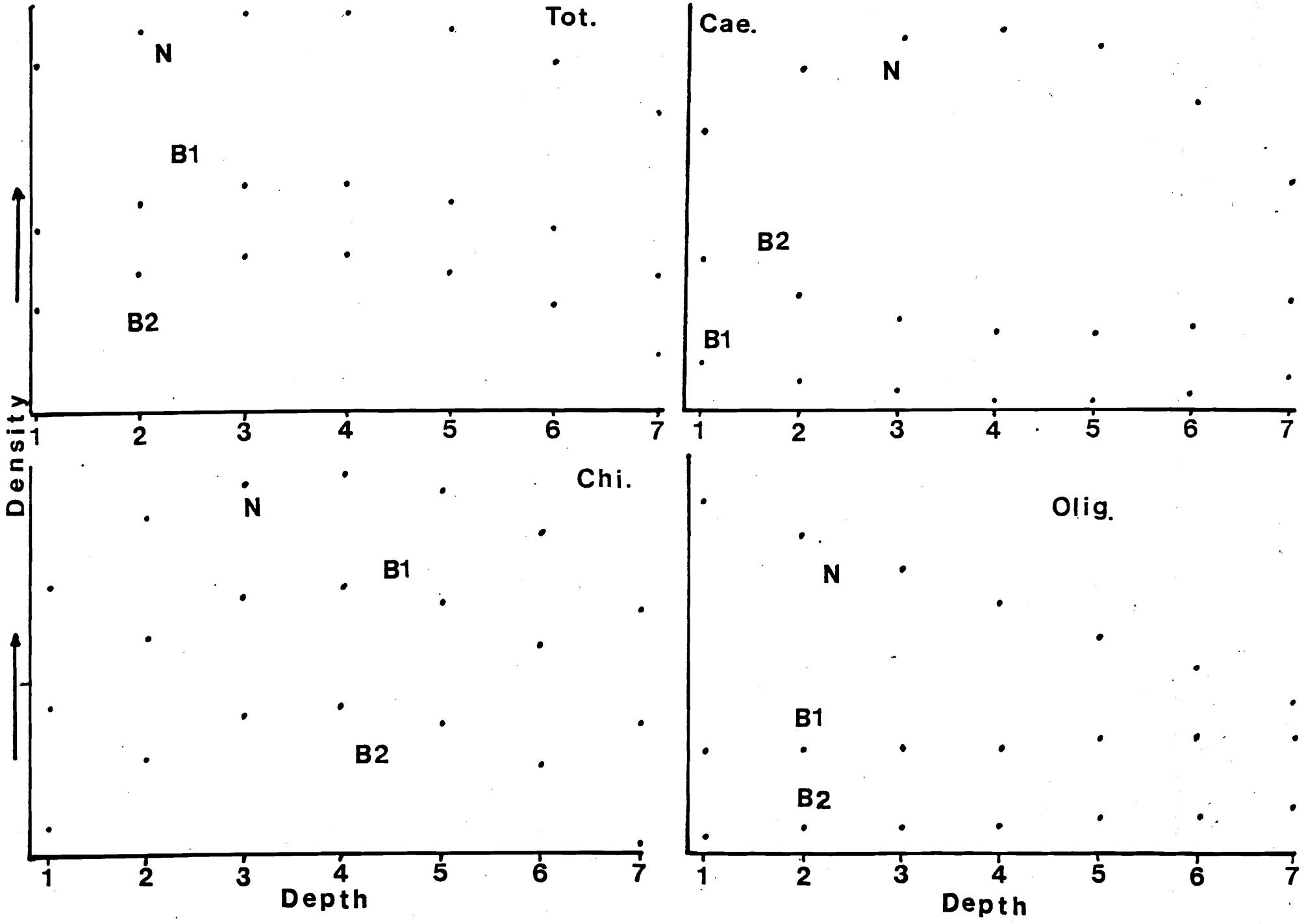
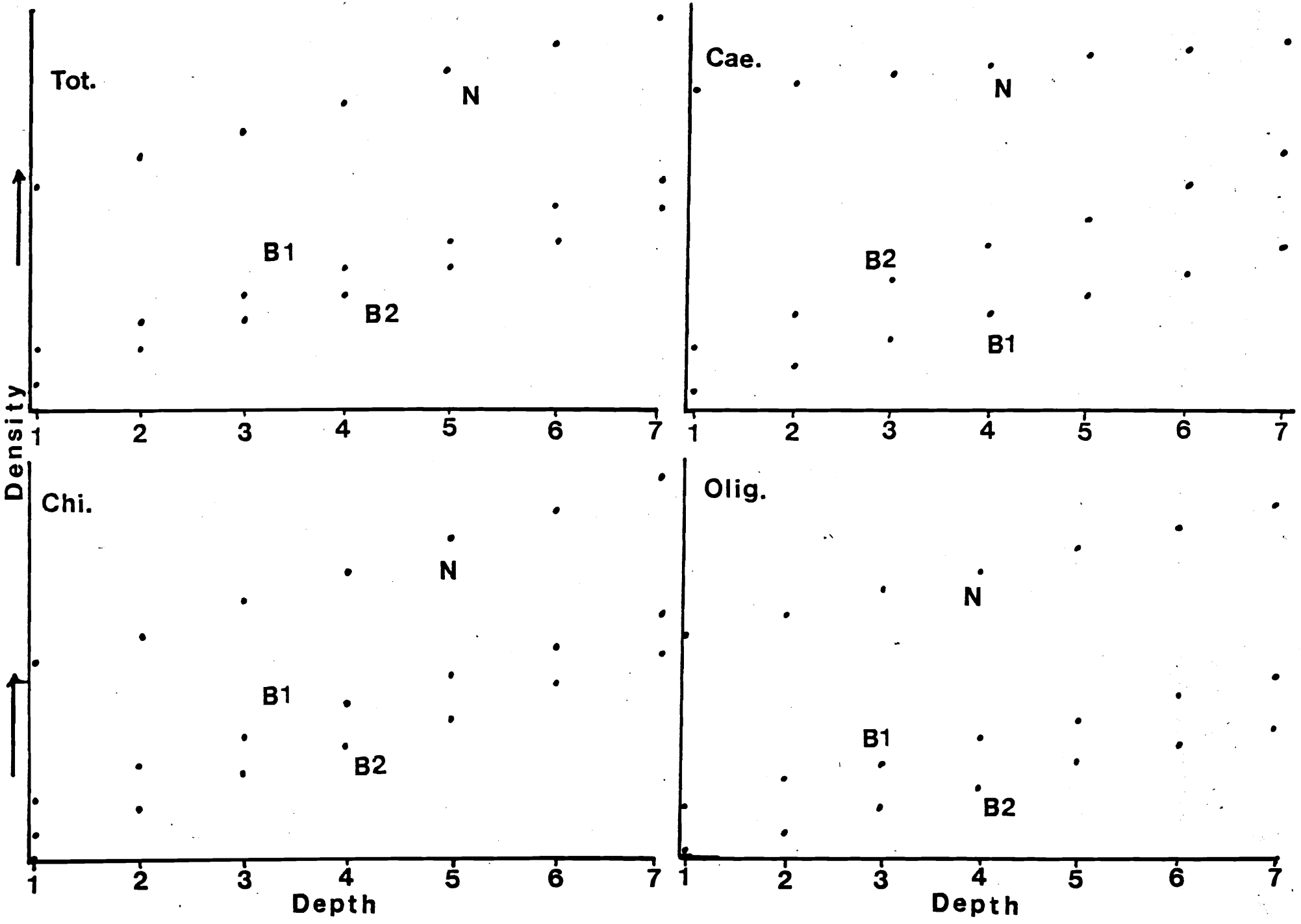

Tot.
N
B1
B2
Cae.
N
B2
B1
Chi.
N
B1
B2
Olig.
N
B1
B2
Density
Depth
Depth
1
2
3
4
5
6
7

Figure 7 shows plotted mean density (square root transformed) of total insects, Caenis sp., Chironomidae, and Oligochaeta by depth from stationary substrate units. The square root transformation of total insects and Chironomidae had a linear response to depth, which was statistically significant. The lines were different when sites 1 and 2 were compared with site 3, but not when site 1 was compared to site 2. Caenis sp. showed a significant response to depth at sites 1 and 2 but not at site 3. Oligochaeta had a quadradic response to depth. Sites 1 and 2 were not different but they were different from site 3. In all cases, at all sites density is higher on the deeper plates, which suggests a behavioral selection by the insects. Density is always much higher at the Niobrara site than at the Boyd County sites, which suggests a peaking effect in Boyd County. The regression lines for total number shows a significant non-zero slope. At site 1 there was a clear separation for total insects.

Figure 7. Plots of regression analyses of square root transformed mean density of invertebrates on units at different depths from stationary platforms.


Tot.
N
B1
B2
Cae.
N
B2
B1
Chi.
N
B1
B2
Olig.
N
B1
B2
Density
Depth
Depth
1
2
3
4
5
6
7

We then tested to see if the response to depth on the stationary platforms was equal or increased as the depth of the plates decreased. There was no difference between numbers of individual organisms on floating units and stationary unit 7, although by the time stationary units 4, 5, 6, and 7 were included in the analyses all tests showed significant differences. This may mean that at some depth below which we measured there will be no significant difference between floating and stationary units. Mean daily discharge for the sampling period was 26,371 cfs and mean daily fluctuation was 14,064 cfs. This translates into a mean daily fluctuation at Greenwood of 32.4 inches. We sampled 22 inches below the maximum stage and the data shows there is a significant difference between floating and stationary units at this point.

Discussion

The extreme magnitude of peaking which occurred during the 18 three-week study (Table 2) was not totally expected when this project was designed. Stationary (fluctuation zone) platforms would have had to cover the range of zero to 45,000 cfs discharge, and units would have had to span nearly 2.8 vertical meters, to provide adequate depth for the lowermost units to have remained submerged during the greatest decline in stage. The only place where this range of depth occurs is in the main channel, and placing units in the main channel imposes problems for equipment maintenance, but also alters the range of current velocities which impinge the units.

To this point we have used the entire data set (17 three-week periods) combined (1 period not included due to method difference). We have found several effects which can be assigned to peaking activity at Fort Randall Dam (ie. reduced standing crop in Boyd County). The effects can be masked somewhat by combining data from such a large time frame. Each three-week period included peaking, however, the magnitude of peaking was not always the same (Figure 5). This eventuality could contribute to masked effected. The insect species studied represented many different organisms with highly diverse life cycles. Several complete generations were reared during this study. Colonization density undoubtedly was affected by larval forms metamorphosing to the adult stage and leaving substrate units. Moreover, the hydraulic dynamics of the Missouri River drainage basin imposes different magnitudes of total discharge on the peaking routine. In other words, peaking occurs at high and low discharge. Colonization of a fresh set of substrate units depends upon several factors including the density of insects in the drift at that time

and the temporal standing stock of Aufwuchs communities near the study areas. Drifting insects and Aufwuch communities can be affected by current velocity, and water volume (Carter et al. 1982, Troelstrup 1985).

We selected 2 three-week periods from the 18 that represented low magnitude peaking (1 May 1987 through 22 May 1987) and high magnitude peaking (4 August 1988 through 23 August 1988). Total mean density was much higher in May 1987 (Table 9). Moreover, the hydraulic history of May, June and July 1988 showed a long period of very high magnitude peaking compared with the period prior to May 1987. We believe the very low density in August 1988 was a result of high magnitude peaking. Even though any type of peaking has a negative impact on Aufwuch insect communities, the effect may be lessened somewhat by a reduced level of peaking discharge fluctuations on a diurnal basis.

Table 9. Mean density of total insects by depth for a low magnitude peaking period (May 1987) and a high magnitude peaking period (August 1988), and the percent of the three-week period each plate was out of water.

	May 1987		August 1988	
Depth	Density	% of period exposed	Density	% of period exposed
1	6.5	99.8	8.75	99.8
2	37.5	94.9	9.25	96.5
3	155.5	70.7	12.50	93.7
4	77.25	66.9	16.0	84.5
5	254.75	62.0	33.5	48.6
6	216.25	55.0	48.25	41.7
7	168.0	45.8	47.75	41.0

We hypothesized that insect larvae could survive a period of habitat dewatering provided the interstitial spaces (between hardboard plates on the substrate units) modified the deteriorating conditions out of water. We felt this could explain the depth related density differences observed on stationary platform substrate units. We tested this hypothesis by calculating the percentage of the 2 three-week periods that units at different depths would have been exposed to the air (Table 9). Since we did not obtain actual elevations of units in the field, we arbitrarily set the uppermost unit at the water surface when the maximum stage was achieved for the period. This was necessary but may have introduced some unrealistic effects. Time of exposure was significantly related to density in a correlation (May 1987: $P = 0.02$, $r = 0.81148$; August 1988: $P = 0.03$, $r = 0.79717$). The longer a unit was exposed to air the lower the density was on that unit. This would suggest that the impact to Aufwuch insect communities could be minimized somewhat by reducing the magnitude of peaking. However, the magnitude would have to be less than even the low magnitude which occurred in May of 1987 (minimum 18,210 cfs up to a maximum of 32,530 cfs).

Troelstrup (1985) investigated peaking effects from Fort Randall Dam on macroinvertebrates along channel margins in Boyd County. He found many similar results, however, a different invertebrate assemblage dominated channel sites including: Polycentropodidae, Hydropsychidae, Hydroptilidae and Heptageniidae.

The three dominants are caddisflies which prefer higher current velocities. He also found that more taxa colonized substrates in Boyd County not impacted by fluctuations and the number of taxa on substrates increased within the fluctuation zone during a year (1984) when high precipitation and runoff prevented the need to peak.

Carr (1988) investigated Fort Randall Dam peaking effects on benthic algae. She summarized the effects as follows:

> " 1) caused a significant reduction in the chlorophyll a biomass of the epilithic algal community of up to a 150-fold; 2) strongly depressed rates of productivity as measured by carbon-14 incorporation; 3) reduced community diversity by up to a factor of 3; 4) altered community structure; and 5) resulted in a suppression of the epilithic algal community to an early successional stage within areas directly subjected to daily water level fluctuations."

Carr (1988) cited studies which clearly demonstrated the importance of benthic algae as a place of refuge, and a food source for macroinvertebrates. Aquatic insects in the Missouri River are important in the diet of nearly all native fish, but also function as the linkage between solar energy stored by terrestrial and aquatic plants and fish. Significant declines in insect abundance will significantly reduce the standing stock of most fish in the Missouri River because few consume plant material directly.

Literature Cited

Carr, J.M. 1988. Biology of benthic algae in the unchannelized Missouri River, Ph.D. Dissertation, University of Nebraska, Lincoln. 22p.

Carter, S.R., K.R. Bazata, and D.L. Anderson. 1982. Macroinvertebrate communities of the channelized Missouri River near two nuclear power stations. In: Hesse et al. (eds.) The Middle Missouri River, Missouri River Study Group, Norfolk, NE. 147-184.

Corps of Engineers. 1985. Missouri River mainstem reservoir annual operating plan. Omaha, NE. 100p.

Cowell, B.C. 1970. The influence of plankton discharges from an upstream reservoir on standing crops in a Missouri River reservoir. Limology and Oceanography. 15: 427-441.

Fisher, S.G. and A. LaVoy. 1972. Differences in littoral fauna due to fluctuating water levels below a hydroelectric dam. J. Fish. Res. Bd. of Can. 29(10): 1472-1476.

Hemsworth, R.J. and M.P. Brooker. 1981. Macroinvertebrate drift in the upper Wye catchment, Wales. Hydrobiologia 85, 145-155.

Hesse, L.W. and J. Klammer. 1984. Missouri River ecology. Performance Report, Dingell-Johnson Project, F-75-R, Nebraska Game and Parks Commission, Norfolk, NE. 68p.

Laflin, B.D. 1981. Fall water level fluctuation and its affects on a sport fishery in a flood control reservoir. Final Report, Dingell Johnson Project, F-42 and F-50. Kentucky Department of Fish and Wildlife Resources, 17p.

Missouri Basin States Association. 1985. Interim report on hydroelectric power generation: Omaha, NE. 37p.

Parsons, D.S. and J.W. Tatum. 1974. A new shallow water multiple-plate sampler. Prog. Fish culturist. 36(3): 179-180.

Pearson, W.D. and D.R. Franklin. 1968. Some factors affecting drift rates of Baetis and Simulidae in a large river. Ecology 49(1): 75-81.

Sale, M.J. 1988. Multiple-resource management of tailwaters for downstream needs. In: S.G. Campbell (ed.), Tailwater Ecology Workshop Proceedings, U.S. Bureau of Reclamation, Denver, CO. p51-52.

Troelstrup, N.H. Jr. 1985. Macroinvertebrate colonization and consumer food habits in the Missouri River of Northeastern Nebraska. M.S. Thesis, University of Nebraska, Lincoln, NE. 180p.

Walburg, C.H. 1976. Changes in the fish population of Lewis and Clark Lake, 1956 - 1974, and their relation to water management and the environment. U.S. Fish and Wildlife Service, Research Report 79, Washington, D.C. 34p.

Ward, J.V. 1976. Effects of flow patterns below large dams on stream benthos: A review. In: Orsborn and Allman (eds.), Instream Flow Needs. Volume 2. Western Division, American Fisheries Society, Bethesda, Maryland, 235-253.

Acknowledgments

Ken Bazata helped with insect identification. Eileen Kirsch, Matt Oates, Joel Klammer and Gene Zuerlein assisted with field work.

Catfish management in the Missouri River with special emphasis on flathead catfish

Larry W. Hesse
Gerald E. Mestl

State of Nebraska
Game and Parks Commission
Fisheries Division

Federal Aid in Fish Restoration
Dingell-Johnson Project
F-75-R-8 Job No. 1

January 1991

Abstract

Channel and flathead catfish in the Missouri River have been over exploited. Commercial harvest of both species will end in 1992, but commercial fishing is only part of the problem. The percentage of channel and flathead catfish longer than 18 to 20 inches is very low at the present. CPUE of flathead catfish from telephone generator samples from the upper unchannelized Missouri River is only 10% of the values from the lower unchannelized reach. Lower unchannelized CPUE is only half of the CPUE of channelized sites. The difference between mean CPUE from unchannelized and channelized collections was highly significant. Tagging has revealed that the population of flathead catfish in the upper unchannelized reach is extremely low. We believe that over harvest, reduced turbidity, and the barricade of Gavins Point Dam has caused the reduced population density. Our management tools include restricted harvest, a closed area, and planning for possible protected size classes. Our objectives will include the protection of the breeding stock and an increase in the percentage of channel and flathead catfish in size groups longer than 24 inches.

Key Words: Catfish, channel, flathead, rivers, regulations, electrofishing, population size, turbidity, fish bypass.

Introduction

Hesse and Mestl (1990) pointed out that channel catfish and flathead catfish in the Missouri River adjacent to Nebraska have been over exploited. Commercial net fishing is responsible for the largest portion of the harvest; however, set-line and/or trot-line fishing may contribute significantly to the total harvest. Unattended lines are allowed with liberal hook limitations. Large live bait is most commonly used which selects for the largest catfish. They are placed along catfish travel routes and few hooks are removed once set. Quinn (1990) cites several studies which have shown a 10-fold greater harvest by trot-line fishermen than by angling. Hesse (1980) conducted a creel survey of rod and reel sport fishermen during 1978 and 1979. The mean effort expended during weekdays was 105 hours/day for the entire unchannelized reach downstream from Gavins Point Dam, while the mean effort during weekdays in the entire channelized reach from Sioux City to Rulo was 200 hours/day. One set-line fisherman using 15 hooks will expend 1,800 hours fishing for 5 days. Many thousands of hooks are presently fished on set-lines, trot-lines, limb-lines, and jug-lines throughout the main channel and for some distance into tributary streams. Moreover, Quinn (1990) pointed out that commercial fishermen, employing trot-lines, were much more efficient at harvesting catfish than recreational trot-line fishermen. We believe that since trot-lines are targeted toward the largest specimens in the river and since they are quite numerous, that the use of passive fishing techniques such as set-lines and trot-lines should be controlled at the same time as net fishing is curtailed. Moreover, we must consider limiting the bag limit on catfish for all sport fishermen, initially, followed by liberalized regulations after catfish populations respond.

Methods

The data gathered to help us understand the present and past status of catfish were the result of field surveys dating back to the early 1970's. These collections were made with cheese baited hoopnets of several mesh sizes, boat electrofishing, deep water electrofishing, seining, gill-netting and other methods. These methods have been clearly outlined in several publications (Hesse 1982, Hesse and Mestl 1990).

The most recent field collections occurred in 1990 and were aimed primarily at flathead catfish and its status in the upper unchannelized reach which lies between Fort Randall Dam and Lewis and Clark Lake.. A special effort was made to obtain an extensive

sample of flathead catfish using specialized electrofishing techniques. The catch per unit effort (CPUE) was compared between several locations along the Missouri River.

In addition, we tagged 225 flathead catfish from several locations downstream from the Gavins Point Dam. These tagged fish were then moved around the dam and stocked into the Missouri River at River Mile 841. Tagging occurred in late August and subsequent collections were made several days later in order to attempt the recapture of tagged fish. Recapture collections were confined to an area two miles upstream from the release site of the tagged fish.

Results and Discussion

Growth of Missouri River catfish is at least as good as catfish from neighboring streams (Hesse et al. 1978). The low density of catfish longer than 18 inches in the Missouri River is directly related to harvest pressure (Hesse and Mestl 1990). Table 1 presents the length distributions for channelized Missouri River channel catfish in 1986 (Newcomb 1989). These fish were collected in the winter with long electrode, electrofishing technology. They were from the Tekamah, NE area and represent the best collection of large channel catfish we have found. Most other sites have been represented by much smaller fish. Included in Table 1 is a length distribution from an old sample of channel catfish from the upper Mississippi River. These fish were obtained from commercial fishermen in 1946 (Greenbank and Monson 1947). Finally, we included a collection of channel catfish made from the Crazy Woman Creek in Wyoming (Smith and Hubert 1988). The authors have characterized this population as lightly exploited. They also pointed out that the growing season was shorter than for the Missouri River and that growth of Missouri River channel catfish was faster than for channel catfish in Wyoming. The upper Mississippi River and Crazy Woman Creek populations represent a goal for management of Missouri River populations. Exact emulation is not necessary; however, we have every reason to believe that with strict harvest control, Missouri River channel catfish can grow and survive to provide a highly valuable recreational fishery. Strict harvest controls will be necessary until the population responds, afterward harvest can be liberalized while closely monitoring the length structure for signs of over exploitation.

Table 1. Length-distributions for three populations of channel catfish.

Inch class	Missouri River 1986	Mississippi River 1946	Crazy Woman Creek 1986
12	54%	0%	0%
12-16	23%	0%	0%
16-18	11%	0%	0%
18	5%	28%	16%
19	3%	26%	16%
20	2%	22%	0%
21	1%	11%	14%
22	0.4%	6%	13%
23	0.4%	3%	13%
24	0.4%	3%	14%
25	0.1%	0.7%	11%
26	0%	0.2%	3%
27	0%	0.1%	0%
28	0%	0.2%	0%
29	0%	0.1%	0%
Total fish	1,659	1,704	239

Table 2 presents a length distribution for three populations of flathead catfish. The Missouri River was always known for its large catfish population and for its large catfish specimens. It is apparent that overfishing has limited the potential of flathead catfish survival just as it has done for channel catfish. The Cape Fear (Ashley and Buff 1986) and Flint Rivers (Quinn 1988) in North Carolina and Georgia, respectively, were not native habitat for flatheads; however, after introduction they flourished because they were lightly exploited. These rivers have been dammed and dredged.

Table 2. Length-distributions for three populations of flathead catfish.

Inch class	Missouri River 1989	Cape Fear River 1986	Flint River 1985
12	79%	0%	46%
12-16	16%	0%	17%
16-18	2%	0%	10%
18	2%	10%	5%
19	0.8%	6%	5%
20	0.3%	2%	0%
21	0%	12%	6%
22	0.3%	4%	6%
23	0%	10%	0%
24	0%	7%	4%
25	0%	13%	0%
26	0%	7%	3%
27	0%	3%	2%
28	0%	3%	0%
29	0%	0.5%	2%
30	0%	3%	1%
31	0%	2%	0%
32	0%	3%	0.7%
33	0%	0.5%	0.7%
34	0%	2%	0%
35	0%	3%	0.5%
36	0%	1%	0%
37	0%	0.5%	0.2%
38	0%	3%	0.2%
39	0%	1%	0%
40	0%	4%	0.2%
Total fish	391	184	3,266

Figure 1 depicts the present size distribution of Missouri River flatheads compared with the Flint River and Cape Fear flathead populations. Missouri River flatheads do not survive in significant numbers beyond 20 inches in length.

Figure 1. Number of flathead catfish by 10-inch length groups from three populations.

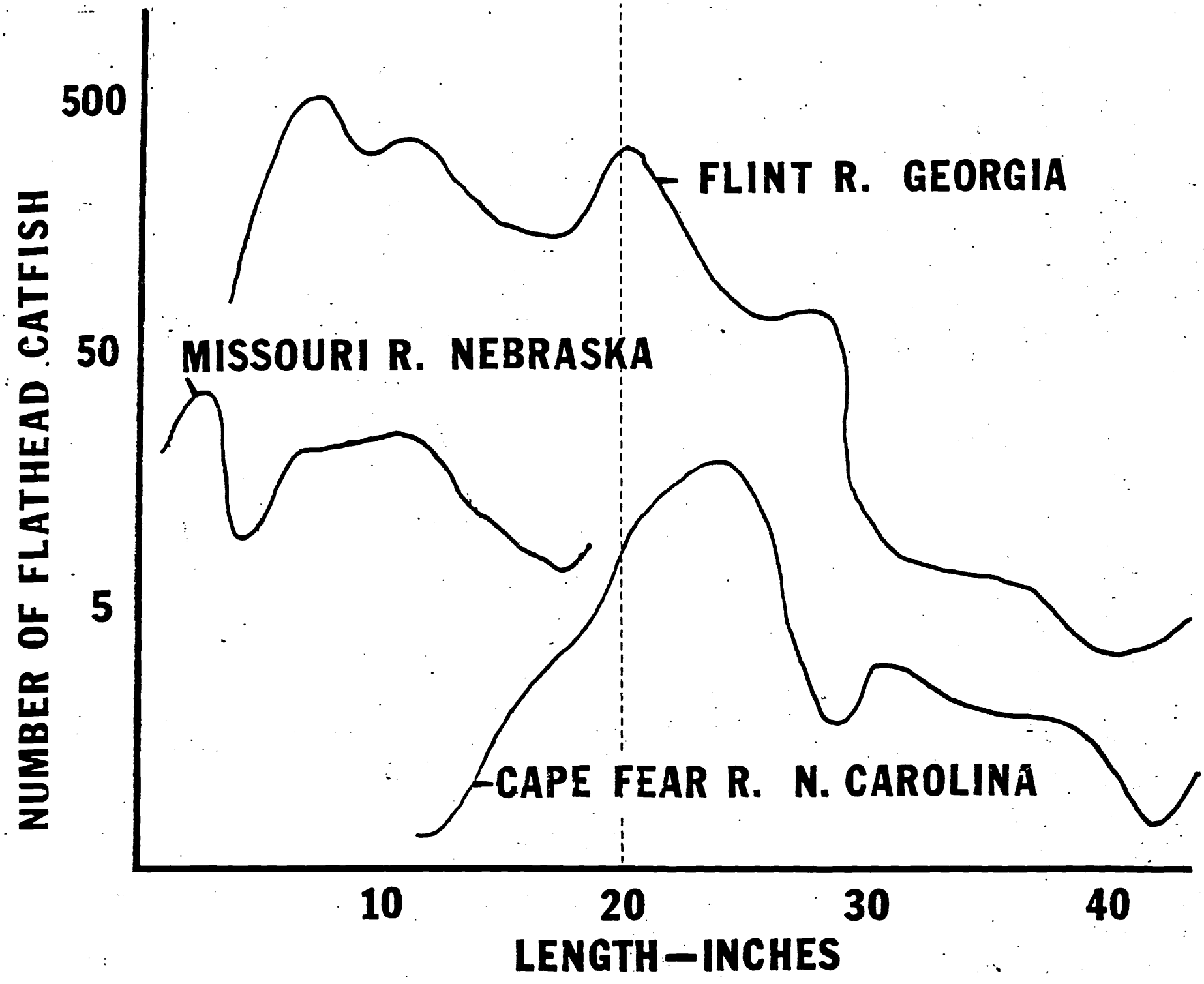

500
50
5
NUMBER OF FLATHEAD CATFISH
FLINT R. GEORGIA
MISSOURI R. NEBRASKA
CAPE FEAR R. N. CAROLINA
10
20
30
40
LENGTH—INCHES

Table 3 shows the percentage of several flathead catfish populations in four selected size groups (Gabelhouse 1984). Data from the Missouri River in Missouri were provided by John Robinson (personal communication, fisheries biologist, Missouri Conservation Commission, Columbia Missouri). A small percentage of Missouri River flatheads were found to survive into size groups preferred by recreational fishermen when compared with several populations subjected to lower exploitation.

Table 3. Comparative relative stock density (RSD) for four populations of flathead catfish. Values are percent of the population.

	Minimum length (in)	Cape Fear	Flint	Missouri River Missouri	Missouri River Nebraska
RSD-quality	16	49	48	3	6
RSD-preferred	24	28	21	1	0
RSD-memorable	28	14	9	0	0
RSD-trophy	36	5	1	0	0

Table 4 presents the results of telephone generator collections of flathead catfish from the lower unchannelized (downstream from Gavins Point Dam) compared with collections from the upper unchannelized section. CPUE is ten times higher in lower unchannelized sections. Additional flatheads were collected during several years of electrofishing using non-flathead electrical settings. Between 1977 and 1987, 11 flatheads were collected from near Niobrara during 2,267 minutes of electrofishing (CPUE equals 0.005). Between 1983 and 1986, 96 flatheads were collected in Cedar County during 1,854 minutes of the same type of electrofishing (CPUE equals 0.05). Once again the difference is a factor of 10. These data suggest upper unchannelized flathead catfish density is only 10% of the population in the lower unchannelized reach.

Table 4. Telephone generator collections of flathead catfish from several different years at several unchannelized locations.

Year	Cedar County			Upstream Niobrara River			Downstream Niobrara River		
	Fish	Minutes	CPUE	Fish	Minutes	CPUE	Fish	Minutes	CPUE
1981		-			-		9	45	0.2
1983	32	47	0.7		-		0	42	0.0
1986	135	73	1.9		-			-	
1987		-			-		0	81	0.0
1988	9	17	0.5		-		1	40	0.03
1990	42	168	0.3	0	134	0.0	31	187	0.2
Total	218	305	0.7	0	134	0.0	41	529	0.08

We have collected flathead catfish from channelized river locations since 1971, however, 1990 data proved adequate to statistically define the difference in density between channelized and unchannelized flathead catfish.

Table 5 shows the results of 1990 collections using the telephone generator. Reach one is the upper and lower unchannelized data and Reach two is channelized data.

Table 5. Flathead catfish collected in 1990 from unchannelized (Reach 1) and channelized (Reach 2) portions of the Missouri River in Nebraska from telephone generator samples.

Reach	Site	Month	Day	Flathead	Effort	CPUE
1	2	8	15	8	36	0.22222
1	2	8	17	8	58	0.13793
1	2	8	28	15	93	0.16129
1	5	8	27	14	72	0.19444
1	6	8	27	22	96	0.22917
1	15	8	28	3	17	0.17647
2	7	8	14	105	76	1.38158
2	7	9	14	23	18	1.27778
2	8	8	7	85	118	0.72034
2	11	8	21	50	28	1.78571
2	11	8	21	45	27	1.66667
2	13	8	20	112	81	1.38272
2	13	9	20	24	35	0.68571
2	13	8	20	61	37	1.64865
2	29	8	22	114	61	1.86885
2	29	8	22	53	31	1.70968

The mean CPUE for Reach one was 0.189 and the mean CPUE for Reach two was 1.301. An analysis of variance showed these means to be significantly different ($P = 0.0001$, $F = 49.62$, $r^2 = 0.7799$).

One week after stocking 225 tagged flathead catfish at River Mile 841, we made several attempts to collect flathead catfish at River Mile 843. We expended 42 minutes electrofishing and collected 11 flatheads (CPUE equals 0.26); six of these flatheads were tagged and released seven days (or longer) prior to this. Moreover, 10 days later one tagged flathead was caught by a sport fisherman at River Mile 827 (14 miles downriver). Since extensive effort was expended to try to collect flathead catfish upstream from the Niobrara River with none collected, we believe flatheads are mostly confined to the reach of river between the Niobrara River and Lewis and Clark Lake (15 miles of river). Tagged fish comprised 55% of the sample from this reach and therefore 225 tagged fish represents 55% of the population in this reach. The population may be only 417 individuals.

Gavins Point Dam prevents immigration into this reach from downstream. Equally important is the lack of turbidity in the upper unchannelized portion of the river which may offset survival. At the time of our flathead collections, covering one 5-day period, secchi dish transparency averaged 1,500 mm upstream from the Niobrara River, 800 m downstream from the Niobrara in the upper unchannelized reach, and 200 mm on the lower channelized reach in Nemaha County. The highest CPUE for flathead catfish occurred in Nemaha County.

Recommendation

The commercial harvest of channel and flathead catfish will end 1 January 1992. Concurrent with the closure of commercial harvest, we recommend that all recreational fishermen should be restricted to 2 lines with 3 hooks. This should apply to rod-reel, set-line, trot-line, limb-line, jug-line or any other form of angling. Bag limits for channel catfish and flathead catfish should be reduced to 5 of each species daily and 10 in possession. The entire Missouri River should be covered by these limits except that all flathead and blue catfish harvest should be stopped from the reach of river upstream from Gavins Point Dam, including Lewis and Clark Lake, to the tailwater of Fort Randall Dam.

The objective of our management should be two-fold. First, we must safeguard the brood population of flathead catfish in the upper unchannelized section until something can be done to correct the sediment/turbidity imbalance (a lack of it) in this reach, and their numbers recover. Blue catfish exist only as rare, and old specimens that should not be killed. Secondly, we should attempt to improve catfish survivability sufficient to increase the percentage of 24 inch and longer fish in the populations. If a reduced bag limit proves insufficient to accomplish the outlined objectives, we should consider implementing a maximum size limit (protecting catfish longer than a specified length).

References

Ashley, K.W. and B. Buff. 1986. Determination of current food habits of flathead catfish in the Cape Fear River. Unpublished report, North Carolina Wildlife Resources Commission, Raleigh, NC. 18 pp.

Gablehouse, D.W., Jr. 1984. A length-categorization system to assess fish stocks. North American Journal of Fisheries Management 4:273-285.

Greenbank, J. and M.A. Monson. 1947. Size and maturity of channel catfish U.M.R.C.C. third progress report of the technical committee for fisheries. St. Paul, MN. 28-31.

Hesse, L.W. and G.E. Mestl. 1990. The status of selected Missouri River stocks and a management plan. Progress Report, D-J Project F-75-R, Nebraska Game and Parks Commission, Norfolk, NE. 47 pp.

Hesse, L.W. 1982. General introduction and methods including acknowledgement. In: L.W. Hesse (ed.). The Missouri River channel catfish, Nebraska Technical Series No. 11, Nebraska Game and Parks Commission, Norfolk, NE. 9-13.

Hesse, L.W. 1980. Creel survey-Missouri River commercial and sport fishermen. Final Report, D-J Project F-15-R, Nebraska Game and Parks Commission, Norfolk, NE. 18 pp.

Hesse, L.W., C.R. Wallace, and L. Lehman. 1978. Fishes of the channelized Missouri River - age-growth, length-frequency, length-weight, coefficient of condition, catch curves and mortality of 25 species of channelized Missouri River fishes. NE Technical Series No. 4. Nebraska Game and Parks Commission, Norfolk, NE. 61 pp.

Newcomb, B.A. 1989. Winter abundance of channel catfish in the channelized Missouri River, Nebraska. North American Journal of Fisheries Management. 9:195-202.

Quinn, S.P. 1988. Flathead catfish abundance and growth in the Flint

River, Georgia. Proceedings Annu. Conf. SEAFWA 42:141-148.

Quinn, S.P. 1990. Development of a recreational fishery for flathead catfish. Publication pending, North American Journal of Fisheries Management. 21 pp.

Smith, J.B. and W.A. Hubert. 1988. Growth, population structure, and mortality of channel catfish from the Powder River and Crazy Woman Creek, Wyoming. Prairie Naturalist 20(3):127-133.

Compendium of fisheries data from the Missouri River, Nebraska.

Gerald E. Mestl
Larry W. Hesse

State of Nebraska
Game and Parks Commission
Fisheries Division

Federal Aid in Fish Restoration
Dingell-Johnson Project
F-75-R-8 Job No. 1

February 1991

Abstract

Nebraska Game and Parks Commission biologists have collected more than 300,000 fish during environmental studies of the Missouri River. These data are most useful to document population trends when the oldest data is compared with the most recent. This project was designed to locate, organize, and computerize these data so they will be more useable. Data are stored on magnetic tape available through an IBM Virtual Machine. The format of these data follow the FIRE 1 format (Hesse 1977). To this date there are 63 data files and 84 species of fish represented. The most recent studies are providing continually updated information to this perspective. A search for more data is underway.

Key Words: Fish, freshwater, data processing, computer use, environment, population, ecosystems.

Introduction

Biologists with Nebraska Game and Parks Commission have collected 297,938 fish from the Missouri River. This total includes fish collected by Nebraska Public Power District (NPPD) and Omaha Public Power District (OPPD) during adult fish surveys related to the operation of Cooper and Fort Calhoun Nuclear Stations. These studies were directed by Game and Parks. Fish collected from tributaries were included when the studies related to specific Missouri River studies. These data have been scattered, in different formats, and not readily available for comparative analyses. Our objectives were to locate all fish collections pertaining to the Missouri River, put these data into one format (Hesse 1977), describe the content of all data files, and reference those people who obtained these data.

Methods

Several types of data sets were created including, annual project data sets and individual species data sets. Federal aid project data were broken down into individual data sets containing all measured fish, for each year of a project or for separate jobs for each year of a project. All data where fish had been only enumerated and not measured were combined into one separate file. Lastly species data sets were created for each species.

All data were stored in an IBM 370 Virtual Machine using the VM/CMS operating system. Data files have a fixed record length of 80 columns with a standard record layout (Table 1). All data files are stored on magnetic tape and are readily transferred to disk storage. Magnetic tapes will be deposited with the Fisheries Division offices in Lincoln and Norfolk. These tape files will be upgraded annually.

Table 1. Standard data format including variable names and assigned columns (Hesse 1977).

Variable	Columns
Site	1 - 3
Station	4 - 5
Day	6 - 7
Month	8 - 9
Year	10 - 11
Collection methods	12 - 13
Number of gear	14 - 15
Unit of effort	16 - 17
Water temperature	18 - 19
Fish number or number of fish	20 - 23
Species	24 - 25
Tag number	26 - 30
Length	31 - 34
Weight	35 - 38
Sex	39
Gonad condition	40
Recapture number or sample number	41 - 45
Age	46 - 47
Annulus 1	48 - 50
Annulus 2	51 - 53
Annulus 3	54 - 56
Annulus 4	57 - 59
Annulus 5	60 - 62
Annulus 6	63 - 65
Annulus 7	66 - 68
Annulus 8	69 - 71
Annulus 9	72 - 74
Annulus 10	75 - 77
Scale edge	78 - 80

Site is a three digit numeric code which designates the main collection area, usually centered around a boat access site or the lower reach of a tributary (Table 2). Station is a two digit numeric code which can designate a specific sampling location, a habitat type or a specific gear type and is dependent on sampling method (Table 3).

Day, Month and Year are two digit numeric representations of the sampling date. Method is a two digit numeric code which designates sampling method (Table 4). Number of gear is a two digit summarization of the number of sampling gear (nets, traps, etc.) from which the data is combined into a single sample. Unit of effort is a two digit representation of the amount of collecting effort expended (minutes, net nights, seine hauls, dredge samples, etc.) when the data is recorded as a single sample. Temperature is the water temperature in Celsius.

Table 2. Missouri River collection sites.

Site code	River mile	Access/tributary	County
1	866	Sunshine Bottom	Boyd
2	841	Niobrara access	Knox
3	816	Lewis & Clark Lake	Knox
4	810	Gavins Point Dam tailwater	Cedar
5	799	St. Helena	Cedar
6	785	Brooky Bottom Park	Cedar
7	753	Ponca State Park	Dixon
8	732	South Sioux City Park	Dakota
9	691	Decatur Park	Burt
10	673	Pelican Point S.R.A.	Burt
11	648	Blair access	Washington
12	563	Riverside Marina	Otoe
13	535	Brownville S.R.A.	Nemaha
14	498	Rulo Park	Richardson
15	844	Niobrara River	Knox
16	800	James River	Yankton, SD
17	772	Vermillion River	Clay, SD
18	734	Big Sioux River	Plymouth, IA
19	669	Little Sioux River	Harrison, IA

Table 2 continued. Missouri River collection sites.

Site code	River mile	Access/tributary	County
20	664	Soldier River	Harrison, IA
21	635	Boyer River	Pottawattamie, IA
22	595	Platte River	Cass
23	528	Little Nemaha River	Nemaha
24	495	Big Nemaha River	Richardson
25	591	Plattsmouth access	Cass
26	628	Dodge Park	Douglas
27	601	Haywood Park	Sarpy
28	542	Peru access	Nemaha
29	726	Dakota City Park	Dakota
30	776	Maskel access	Dixon
31	787	Myron Grove	Clay, SD
32	780	Clay County Park	Clay, SD
33	764	Bolten Bend	Union, SD
34	-	Unassigned	Dakota
35	-	No access yet	Thurston
36	731	Floyd River	Plymouth, IA
37	638	Boyer Chute	Washington
38	542	Nishnabotna River	Atchison, IA
39	805	Yankton City Park	Yankton, SD
50		Fort Randall Dam tailwater	Charles Mix, SD

Table 3 Station codes used with different sampling methods.

Method	Station code	Designation
All types of electrofishing	01	Revetment (rock lining on cutting bank)
	02	Wing dikes (perpendicular rock spurs on the filling bank)
Hoopnet	01	1/4-inch mesh
	02	1-inch mesh
	03	1 1/2-inch mesh
	04	2-inch mesh
Gillnet	01	300-feet multi-filament sinking experimental
	02	300-feet mono-filament sinking experimental
	03	200-feet multi-filament sinking experimental
	04	3-inch mesh floating
	05	3-inch mesh sinking
	06	300-feet mono-filament floating experimental
Framenet	01	1/4-inch mesh
	02	1-inch mesh
Trawl	01	Deep channel
	02	Shallow floodplain
Plankton nets	01	Cutting bank
	02	Mid-channel
	03	Filling bank

Table 4. Sampling methods and sampling method codes.

01	Boatshock
02	Hoopnet
03	Seine (1/4-inch mesh, 4-feet to 6-feet by 50-feet with a bag)
04	Telephone boatshock
05	Basket trap
06	Trammel net
07	Gill net
08	Set line
09	Frame net
10	Bottom trawl
11	Rotenone
12	Rod and reel
13	Explosive
14	Miller plankton sampler
15	Plankton net (0.75 m diameter, 560 micron mesh)
16	Cast net
17	Box net
18	Multi-plate
19	Peterson dredge (12-inch x 12-inch)

Table 4 Continued. Sampling methods and sampling method codes.

20	Core sampler
21	Night boatshock
22	24-hour drift
23	Verticle multi-plates
24	Small ekman dredge (6-inch x 6-inch)
25	Open
26	Plankton net (1 m diameter, 560 micron mesh)
27	Rectangular drift net (12-inch x 12-inch)
28	Pipe dredge
29	Mid-water trawl
30	Commercial seine (1-inch mesh, 14-feet x 450-feet)
31	Large ekman dredge (12-inch x 12-inch)
32	Orangepeel dredge
33	Long electrodes
34	Creel census

Fish number is a unique number assigned to an individual fish. Number of fish is the number of fish of a single species collected in that sample. Species is a two digit numeric code from a species code list (Table 5). Tag number is a 5 digit alphanumeric designation.

Length is the total length of a fish in millimeters or, in the case of paddlefish, the eye to fork length in millimeters. Weight is the weight of an individual fish in grams or, in the case of paddlefish, the weight of the paddlefish divided by ten. Sex is a one digit alphanumeric code for the sex of an individual fish; 1 or M for male and 2 or F for female. Gonad is a one digit numeric code for the condition of an individual fish's gonads (Table 6). Recapture number is a recaptured tag number or recapture code (based on a fin clip). Sample number is a unique number assigned to a sample.

Table 5. Missouri River fish species and their two digit codes.

01 Chestnut lamprey	02 Lake sturgeon	03 Pallid sturgeon
04 Shovelnose sturgeon	05 Paddlefish	06 Longnose gar
07 Shortnose gar	08 Bowfin	09 Alewife
10 Gizzard shad	11 Skipjack herring	12 Goldeye
13	14 Rainbow trout	15
16	17 Brown trout	18 Northern pike
19 Grass pickerel	20 Muskellunge	21 Tiger muskellunge
22 Carp	23 Goldfish	24 Stoneroller
25 Brassy minnow	26 Silvery minnow	27 Plains minnow
28 Speckled chub	29 Flathead chub	30 Silver chub
31 Creek chub	32 Blacknose dace	33 Longnose dace
34 Northern redbelly dace	35 Sicklefin chub	36 Sturgeon chub
37 Golden shiner	38 Emerald shiner	39 River shiner
40	41 Bigmouth siner	42 Red shiner
43 Sand shiner	44 Suckermouth minnow	45 Bluntnose minnow
46 Fathead minnow	47 River carpsucker	48 Quillback carpsucker
49 White sucker	50 Longnose sucker	51 Blue sucker
52 Smallmouth buffalo	53 Bigmouth buffalo	54 Black buffalo
55 Shorthead redhorse	56 Black bullhead	57 Yellow bullhead
58	59 Channel catfish	60 Flathead catfish
61 Blue catfish	62 Stonecat	63 Tadpole madtom
64 American eel	65 Plains top minnow	66 Plains killifish
67 Brook stickleback	68 Burbot	69 White bass
70	71 Striped bass	72 Striped bass x white bass
73	74 Rock bass	
75 Largemouth bass	76 Smallmouth bass	77 Spotted bass
78 Green sunfish	79 Orange spotted sunfish	80 Pumpkinseed
81		82
83 Bluegill	84 Black crappie	85 White crappie
86 Iowa darter	87 Spotfin shiner	88 Johnny darter
89 Yellow perch	90 Sauger	91 Walleye
92 Freshwater drum	93	94 White amur
95 Spottail shiner	96	97 Rainbow smelt
98	99	

Table 6. Gonad codes and their definitions.

Code	Definition
1	Immature male
2	Mature male
3	Milt male
4	Immature female
5	Mature female
6	Gravid female
7	Ripe female
8	Spent female

Age is a two digit numeric value. Fish are assigned one more year on 1 January each year. Annulus 1 - Annulus 10 are three digit numeric representations of annulus measurements. Edge is a three digit representation of the scale, jaw, otilith or spine edge measurements.

Table 7. Name of the data sets created including project identification, sites sampled, methods used and number of fish.

File	Name	Project number	Sites	Methods	Number of fish
NIOB	DATA69	2332-59	15	02	52
FISH	DATA70	2332-59	11-13	01-02-04-08	1851
NIOB	DATA70	2332-59	15	02	36
THERMAL	DATA70	F-4-R	11-13	01-02	166
THERMAL	DATA71	F-4-R	11-13	01-02-04	10489
NALCO	DATA72	NPPD/OPPD	13	01	892
PADDLE	DATA72	2332-59	5 - 7	07	349
THERMAL	DATA72	F-4-R	11	01	8
NALCO	DATA73	NPPD/OPPD	11-13	01	1995
NALCO	DATA74	NPPD/OPPD	11-13	01	2001
THERMAL1	DATA74	F-4-R	11-13	01-02-03-04-05-07-08	7450
THERMAL2	DATA74	F-4-R	11-13	01	10056
NALCO	DATA75	NPPD/OPPD	11-13	01	1558
THERMAL1	DATA75	F-4-R	11-13	01-04	9109
THERMAL2	DATA75	F-4-R	11-13	01-02-04-05	8112
2257R	DATA75	2-257-R	1-5-6-8	01-02	2996
MONEMA	DATA76	2-283-R	13	02-05	730
MONIOB	DATA76	F-10-R	2-15	01-02-06-09	1652
NALCO	DATA76	NPPD/OPPD	11	01	3064
NEMACAT	DATA76	2-283-R	23	01-02	1376
2257R	DATA76	2-257-R	1-5-6-8	01-02	5873

Table 7 continued. Name of the data sets created including project identification, sites sampled, methods used and number of fish.

File	Name	Number	Sites	Methods	Number of fish
MONEMA	DATA77	2-283-R	13	02	1091
MONIOB	DATA77	F-10-R	2-15	01-02-06-07	2045
NALCO	DATA77	NPPD/OPPD	11	01	2882
NEMACAT	DATA77	2-283-R	23	01-02	593
2257R	DATA77	2-257-R	5-6-8	01-02	4421
NALCO	DATA78	NPPD/OPPD	11-13	01	29
NEMACAT	DATA78	2-283-R	23	01-02	1078
PRIME	DATA78	2-283-R	24	13	1339
2257R	DATA78	2-257-R	5-6-8	02-32	2987
HOOPNET	DATA79	F-10-R	15	02	249
FISH	DATA80	F-55-R	2	07-09	404
POPEST	DATA80	2-359-R	9	04	95
UPPNIOB	DATA80	2332-59	15	02	250
FISH	DATA81	F-55-R	1	01-02-08-09	159
F15R4	DATA81	F-15-R-4	2-10	01-02-08	461
LEWCLARK	DATA81	F-15-R	3	03-10	3915
POPEST	DATA81	2-359-R	9-10	33	1717
FISH	DATA82	F-55-R	2	01-02-07-08-11	678
PADDLE	DATA82	District3	4	34	281
FISH	DATA83	F-75-R	1-2-4-5	01-02-04-07-21	3359
LARVFISH	DATA83	F-75-R	1-2-4-5-6	15	782
SEINE	DATA83	F-75-R	1-2-4-5	03	4711

Table 7 continued. Name of the data sets created including project identification, sites sampled, methods used and number of fish.

File	Name	Number	Sites	Methods	Number of fish
FISH	DATA84	F-75-R	1-2-4-5	01-02-07-10-21	2519
LARVFISH	DATA84	F-75-R	1-2-4-5-6	15	5190
PADDLE	DATA84	District3	4	34	172
SEINE	DATA84	F-75-R	1-2-4-5	03	4794
FISH	DATA85	F-75-R	1-2-4-5-11	01-02-05-07-21-32	2196
LARVFISH	DATA85	F-75-R	1-2-4-5-6	15	4133
PADDLE	DATA85	District3	4	34	157
SEINE	DATA85	F-75-R	1-2-4-5-11	03	7092
FISH	DATA86	F-75-R	1-2-4-5-7-8-10-11	02-04-07-10-21-32	3730
LARVFISH	DATA86	F-75-R	1-2-4-5-7-8-10-11	26	4350
PADDLE	DATA86	District3	4	34	355
SEINE	DATA86	F-75-R	1-2-4-5-7-8-10-11	03	3552
FISH	DATA87	F-75-R	1-2-3-4-5-6-7-8-9-10	01-02-07-21-30-33	2309
PADDLE	DATA87	F-75-R	4	34	368
FISH	DATA88	F-75-R	1-2-4-5-6-7-8-9-10	01-02-07-09-33	3475

Table 7 continued. Name of the data sets created including project identification, sites sampled, methods used and number of fish.

File	Name	Number	Sites	Methods	Number of fish
PADDLE	DATA88	F-75-R	4-5-7-31-39	34	646
FISH	DATA89	F-75-R	1-2-4-5-6-7 -8-9-10-11- -12-13-18-25	01-02-04-07-10-21-33	2520
PADDLE	DATA89	F-75-R	4	34	1377
FISH	DATA90	F-75-R	1-2	34	3685
PADDLE	DATA90	F-75-R	4	34	1775

Results

Sixty-two data sets were created that contain measured fish (Table 7). A single file containing all fish not measured was also created. The data were summarized by species, including the number of measured and non-measured fish (Table 8). Eight-four different species have been collected. Measured fish account for 50% (147,899) of the total 297,550 fish. This listing represents common and uncommon fish collections dating between 1969 through 1990. We will use this information to effectively track the change in status of species living in the Missouri River and its tributaries. We can readily print out a listing of any species file which will provide evidence of catch and effort during extended time periods. The management objective of most Missouri River studies from Nebraska Game and Parks has been to define ecosystem impacts resulting from human intrusions. In that light, the collections were made in an effort to study all species not just those perceived as having importance to fishermen.

Table 8. Total number of measured and non-measured fish collected, by species, from the Missouri River, Nebraska.

Species	Measured fish	Non-measured fish	Total
Shovelnose sturgeon	184	1	185
Paddlefish	5,764	453	6,217
Longnose gar	144	2	146
Shortnose gar	1,053	27	1,080
Bowfin	1	0	1
American eel	39	0	39
Skipjack herring	45	8	53
Alewife	0	9	0
Gizzard shad	13,424	5,650	19,074
Goldeye	3,949	1,448	5,397
Rainbow trout	1	0	1
Brown trout	2	0	2
Rainbow smelt	59	51	110
Grass pickerel	2	4	6
Tiger muskellunge	1	1	2
Northern pike	250	43	293
Muskellunge	6	0	6
Tiger muskellunge	1	1	2
Stoneroller	5	2	7
Goldfish	22	6	28
Carp	22,100	6,515	28,615

Table 8 Continued. Total number of measured and non-measured fish collected, by species, from the Missouri River, Nebraska.

Species	Measured fish	Non-measured fish	Total
Brassy minnow	2	6	8
Silvery minnow	83	5,199	5,282
Plains minnow	0	62	0
Speckled chub	1	74	75
Sturgeon chub	1	0	1
Flathead chub	9	3,721	3,730
Sicklefin chub	1	0	1
Silver chub	170	1,607	1,777
Emerald shiner	13,220	21,936	35,156
River shiner	151	8,246	8,397
Bigmouth shiner	184	998	1,182
Spottail shiner	89	51	140
Red shiner	1,098	8,246	9,344
Spotfin shiner	890	850	1,740
Sand shiner	1,122	12,945	14,067
Suckermouth minnow	3	3	6
Northern redbelly dace	4	0	4
Bluntnose minnow	45	1	45
Fathead minnow	374	222	596
Blacknose dace	2	2	4
Creek chub	28	11	39

Table 8 continued. Total number of measured and non-measured fish collected, by species, from the Missouri River, Nebraska.

Species	Measured fish	Non-measured fish	Total
River carpsucker	14,401	10,596	24,997
Quillback carpsucker	121	2	123
White sucker	78	13	91
Blue sucker	938	55	993
Smallmouth buffalo	2,312	1,525	3,837
Bigmouth buffalo	1,482	965	2,447
Black buffalo	3	0	3
Shorthead redhorse	2,119	312	243
Blue catfish	22	10	32
Black bullhead	332	36	368
Yellow bullhead	16	0	16
Channel catfish	36,325	5,727	42,052
Stonecat	159	30	189
Tadpole madtom	3	7	10
Flathead catfish	4,988	374	5,362
Burbot	32	0	32
Plains killifish	0	6	0
Plains topminnow	0	1	1
Brook stickleback	1	0	1

Table 8 continued. Total number of measured and non-measured fish collected, by species, from the Missouri River, Nebraska.

Species	Measured fish	Non-measured fish	Total
White bass	2,676	3,003	5,679
Striped bass	0	1	1
Striped bass x white bass	4	0	4
Rock bass	105	5	110
Green sunfish	262	456	718
Pumpkinseed	6	0	6
Orangespotted sunfish	71	10	81
Bluegill	665	1,334	1,999
Smallmouth bass	616	72	688
Spotted bass	4	0	4
Largemouth bass	504	64	568
White crappie	589	229	818
Black crappie	675	484	1,159
Iowa darter	1	0	1
Johnny darter	123	32	155
Yellow perch	500	173	673
Sauger	2,641	561	3,202
Walleye	757	121	878
Freshwater drum	10,195	45,143	55,338
Grass carp	1	2	3

Many biologists have contributed to the collection of these data. Niob Data69 and Data70 were obtained by Stan Moberly, District III Supervisor with help from Alan Carson, Robert Chlupach and Lynn Schlueter. Fish Data70 were from the pre-operational studies regarding fish effects from the construction and operation of Cooper and Fort Calhoun Nuclear Stations (Thermal Study). The principal investigator was Larry Morris. The following biologists contributed time to the field collection activity: Darrell Feit, Alan Carson, Quentin Bliss, Don Kline, Larry Messman, Larry Zadina, Larry Hutchinson, Don Rockford, Jerry Morris, and Norman Stucky. Thermal Data70 and Thermal Data71 were acquired by these same individuals. Nalco Data72 were contributed by the Cooper Nuclear Power Station's consultant. Initially this was Industrial Bio-Test. In 1975 they were purchased by Nalco Environmental Sciences. The principal investigator was Steve Reetz assisted by D.E. Patulski. The principal investigator during the 1972 Thermal Study collections was Norman Stucky. He was assisted by Jerry Stefferud as well as many others already listed. Paddle Data72 were collected by Donald Friberg with South Dakota Game, Fish and Parks and Allan Carson with Nebraska. Lee Rupp helped with these fish. Steve Reetz remained as the principal investigator for Nalco through 1978. Fisheries workers were Donald Szamania, Quentin Bliss, and Ronald King. Thermal Study data files from 1974 and 1975 were gathered under the supervision of Charles Wallace for Nebraska Game and Parks; assistants included Larry Hesse, Larry Lehman, and Arthur Stewart. Iowa Conservation Commission biologists provided additional help. Most noteworthy would have been Kay Hill, Larry Jepner, and Jerry Hudson. The data file labeled 2257R represents data gathered by Darrel Feit and Steve Schainost with help from Arthur Atewart, Dave King, Mike Avery, Tom Kiritsy, and Dave Tunink. Nemaha River studies were carried out by Larry Hesse and Larry Zadina with help from Gene Zuerlein, Brad Newcomb, Leigh Ann Retelsdorf, Len Koziol, and Randy Winter. Lower Niobrara River studies were carried out by Larry Hesse with help from Gene Zuerlein, Roger Vancil, Len Zoziol, Brad Newcomb, Leigh Ann Retelsdorf, Lee Rupp and Arthur Stewart. Upper Niobrara River studies were carried out by Larry Hutchinson and Lynn Schlueter.

Several projects were completed during 1980-1982. These were projects carried out by Larry Hesse with help from Brad Newcomb, Joel Klammer, Jeff Schuckman and Arthur Stewart.

The most recent studies (since 1983) have been carried out by Larry Hesse with help from Gerald Mestl, Joel Klammer, David Overhue, Heather Wright, Scott Wessel, Nile Kemble, Nancy Cole, Steve Schleiger, Natalie Newland, Marla Rohrke, Brett Kolterman, David Schumacher, Pat O'Brien, Joe Cassidy, Melanie Vorderstrasse, Cynthia Trail-Cook and Theresa Smydra.

More than 60 technical papers have been generated by this data and the data continues to accumulate. The most significant insight has come from comparing the oldest with the newest data. Each year now adds a great deal of useful information because we have a large and long-term perspective. The fact is that because of man's intrusion into the Missouri River ecosystem, destabilized populations will not recover for a long time to come. The best we can hope for is to continue tracking these changes while we look for solutions to environmental problems.

In addition to the studies listed, there are several that were not available for inclusion this year. These data sets will be entered and will appear along with the 1991 udpate in 1992. There were several studies carried out during the 1960's by Game and Parks' biologists, however, we have been unable to locate the original data. It is possible these data were destroyed; if it's located, we will include it in future listings.

Literature Cited

Hesse, L.W. 1977. FIRE 1 a computer program for the computation of fishery statistics on samples with aged and non-aged subsamples. Nebraska Technical Series No. 1, Nebraska Game and Parks Commission, Lincoln, NE. 60 p.

Filename = 1990djrp script