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DEDICATION

This paper is dedicated to one of the authors, Len Koziol. Len was a student at the University of Nebraska, Lincoln, during the course of this investigation. He worked part-time in the fall and winter serving as a valuable aide in processing the data, and he worked full-time as a summer aide during the field sampling. Shortly after this study was completed, Len obtained a permanent position with the Wildlife Division of Nebraska Game and Parks Commission. During an aerial deer survey on January 25, 1979, he and three other agency employees crashed and two biologists were killed; Len survived but the accident left him with a serious brain injury. All of the authors miss Len and pray for his recovery. Len was a serious, dedicated student of wild populations. His deep involvement in the Niobrara-Missouri River studies make dedication of this paper to him highly appropriate.

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CONTENTS

A biologist completes the attachment of the electrical blasting cap to a standard length of explosive (Primacord).

The 13-meter charge of Primacord sent a shower of water and an occasional fish high into the air. A block net was situated just below the charge.

INTRODUCTION

The Niobrara River heads in the table lands of eastern Wyoming and flows 786 kilometers (km) eastward across Nebraska joining the Missouri River near the town of Niobrara, Nebraska. The Niobrara is the largest Missouri River tributary between the last two mainstem impoundments (Lake Francis Case and Lewis and Clark Lake).

Fish movement up the Niobrara is prevented by Nebraska Public Power District's (NPPD's) Spencer Hydroelectric Dam, 63.3 km upstream from the river mouth. The lower reach of the river is turbid and carries a considerable load of sand, silt, and organic debris into the Missouri River. The mean annual flow is 49.5 m^3/s. The mean annual flow through Spencer Dam for the period September 1976 through September 1977 was 37.7 m^3/s. Silt, sand, and debris settle into the reservoir behind Spencer Dam. Periodic flushing is needed to prevent damage to the turbines. Quarterly flushings have resulted in significant fish kills downstream from Spencer Dam (Hesse 1976, Hesse 1977, Wallace 1976).

Niobrara River fish populations have not been studied previously. In contrast, the fishery of the Missouri River-Lewis and Clark Lake system was studied by the U.S. Fish and Wildlife Service from 1962-1974 (Walburg 1976). Walburg alluded to the beneficial relationship that potentially exists between the Niobrara and Missouri river systems.

The fishery in Lewis and Clark Lake has been declining since 1959 for reasons that are well defined (Walburg 1964, Walburg 1976). The Niobrara is a major tributary and may offer a better spawning and nursery environment than the Missouri-Lewis and Clark system. This study was designed to distinguish the relationship existing between the fisheries of these two systems and establish a baseline of life history data for Niobrara fishes for future reference. This information is especially valuable, since proposals by the U.S. Bureau of Reclamation would create an impoundment on the Niobrara (O'Neill-Norden Dam Irrigation Project) approximately 208 km upstream from the mouth of the river. Should this project become reality, flows in the Niobrara at Norden, Nebraska, would be reduced from the 21.9 m^3/s mean annual flow for the period 1964-73 (Nebraska Natural Resources Commission 1976). Projected flow through Norden Dam would be 5.7 m^3/s for 60% of the time (personal communication with Roger Andrews, U.S. Bureau of Reclamation). Reduced flow will surely restrict fisheries habitat in the lower Niobrara. If the Niobrara River is a significant contributor to the fishery of the Missouri River - Lewis and Clark Lake system, a loss of fish habitat in the Niobrara could have a detrimental effect on the fishery of the larger system. Collection of data at this time will aid in the assessment of such losses if they occur.

METHODS

Fish were sampled from the Niobrara and Missouri rivers in August, September, and October of 1976 and monthly from April through September of 1977. All efforts were geared to sampling channel catfish (*Ictalurus punctatus*), sauger (*Stizostedion candense*), walleye (*Stizostedion vitreum vitreum*), young-of-the-year of all species, and forage fishes.

Cheese-baited hoopnets, seines, plankton nets and explosives were used to collect fish from the Niobrara. Six stations were established between the mouth and Spencer Dam (Figure 1). The stations and their distance from the mouth of the Niobrara include:

Station 1: Downstream from U.S. Highway 12 bridge –– 1.6 km
Station 2: Upstream from U.S. Highway 12 bridge –– 2.2 km
Station 3: South of Verdel, Nebraska –– 24.2 km
Station 4: South of Lynch, Nebraska –– 45.0 km
Station 5: South of Bristow, Nebraska –– 56.2 km
Station 6: South of Spencer, Nebraska –– 63.0 km

Station 7 was established in April 1977, 3.7 km upstream from Spencer Dam and 66.7 km from the mouth of the Niobrara.

Hoopnets were 0.61 meters in diameter and 3.05 meters long with 25 mm mesh (square measure) throughout. These were baited with yellow cheese trimmings and fished for two nights each month at each station on the Niobrara. The number of nets fished varied with water conditions, so catch per net per night was used as a standard unit of comparison. All catfish captured were weighed (grams) and measured (mm total length, TL). Channel catfish 200 mm TL or longer were tagged with a modified Carlin tag (Carlin 1954). Tags were 0.45 mm diameter stainless steel wire bridle, placed through the musculature below the dorsal fin. A 25 mm extention of this bridle carried a 14 mm X 8 mm oval-shaped, vinyl tag with a return address.

A standard seine haul (25 meters) was made at each station on the Niobrara once each month, unless water flucuations prevented use of the seines. All seines were 10 meters long, 1.2 meters deep, and 6 mm mesh including a central bag. All fish captured were preserved and returned to the laboratory for identification and enumeration.

Ichthyoplankton and zooplankton drift was sampled twice each month from April through August 1977. The need to sample in shallow water prompted construction of plankton nets with a rectangular mouth. Nets were 1.37 m long with a mouth surface area of 0.114 m^2, mesh size was No. 0 Nitex mesh (0.571 mm apertures). A station sample consisted of two, 15-minute sets. The nets were anchored in the current and each carried a calibrated, General Oceanics Model 2030 flowmeter suspended in the mouth of the net. Samples were preserved in 10% formalin, returned to the laboratory, and stained with Rose Bengal.

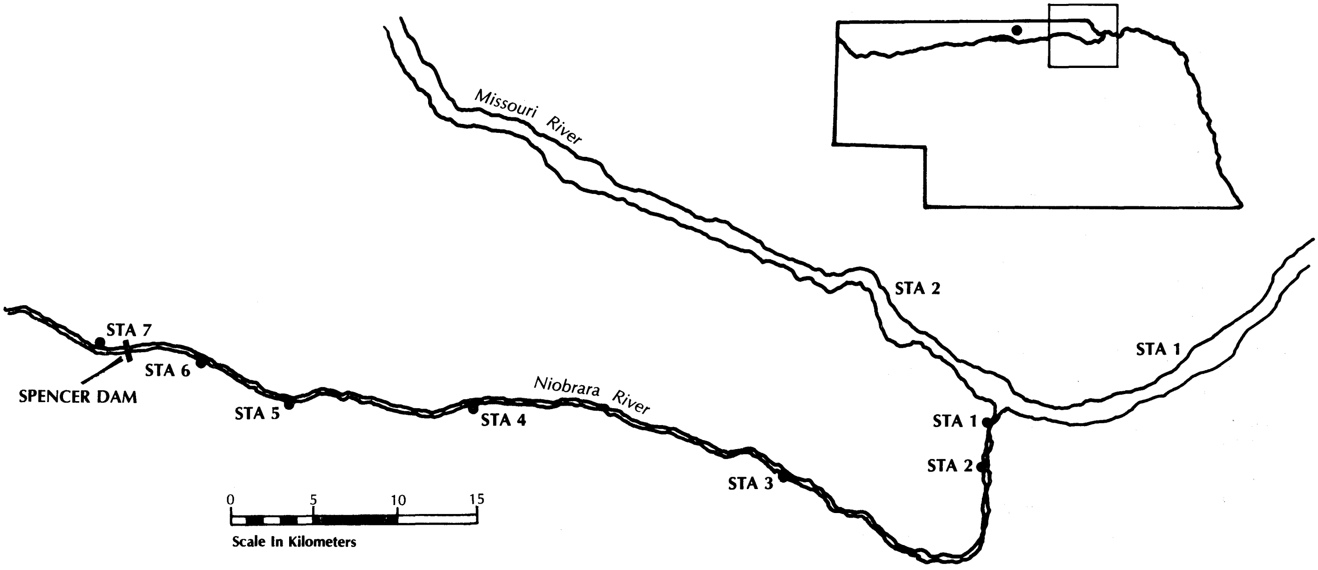

Figure 1. Niobrara and Missouri River sampling stations, 1976-1977.

Larval fish were identified with the aid of several taxonomic keys (Hogue, et. al. 1976, Lippson and Moran 1974, May and Gasaway 1967, Nelson 1968, Taubert 1977). Group descriptions and terminology follow Hogue, et. al (1976). Zooplankton samples were subsampled with a Hensen-Stempel pipette and sorted to major taxonomic group (Edmondson 1959). Counts of each group were performed on a Ward rotary counting chamber. Mean numbers were determined from two or three replicates and expanded to show the number per cubic meter.

An explosive (Primacord) was used to sample the Niobrara on five occasions from June through September 1977. A unit of effort consisted of a 15.2 meter length of explosive, containing 162.5 grains of PETN per meter. Samples were taken along banks where vegetation grew into the water, providing protective cover, and from mid-bar rivulet habitat often less than 0.5 meters deep. Bag seines of 6.35 mm mesh were held stationary in the current below the blast site to retrieve stunned or killed fish. Samples were returned to the laboratory for identification and enumeration.

On September 17, 1977, the Nebraska Air National Guard aerially photographed the Niobrara River from its mouth to the uppermost station on nine-inch, black-and-white film. Contact prints were subsequently made and trimmed to define the river in its entirety. A mean scale of 1:10048 ± 572 (SD) was used in the estimation of total surface area of habitable river based on polar planimeter readings. Total bankline, similar to that sampled with explosive, was estimated from the aerial photos with a map reader.

The Missouri River was separated into two stations. Station 1 extended from the mouth of the Niobrara River east (downstream) into Lewis and Clark Lake; Station 2 went from the mouth of the Niobrara River west (Figure 1).

Cheese-baited hoopnets were fished at each station for two nights each month in August, September, and October 1976 and April through September 1977. A standard seine haul was made at each station once each month. Dimensions of the hoopnets and seines were the same as those fished in the Niobrara. Pulsed DC electrofishing was attempted once each month, both during daylight and darkness. Only sauger, walleye, and catfish were studied. Experimental gill nets (90 meters) and trammel nets (46 meters) were fished during August and September 1977. Sets were made overnight in chutes and on marshy bars. Drift samples were taken twice each month from each station from April through September 1977. A station sample consisted of three, 12-minute tows (one from near each bank and one from mid-river). Larger nets were used in the Missouri than in the Niobrara (2.41 meters long and 0.4357 m^2 mouth surface area). Each had a flowmeter in the mouth and was held steady in the current with the boat. All nets were fished near the surface.

Whenever possible, catfish were externally sexed. Spines were removed from a large sample of catfish and scales taken from all sauger and walleye. Catfish, sauger, and walleye stomachs were collected and preserved in 10% formalin to evaluate food habits. Stomach contents were placed in a petri dish and examined under a stereoscopic microscope fitted with 10X eyepieces and a 1.5X auxiliary lens. Number and frequency of occurrence of each food item was recorded. Stomach contents were identified from keys found in Ross (1944), Wiggins (1977), Borror et. al (1976), Pennak (1953), Usinger (1971), Johannsen (1969), Edmunds et. al (1976), and Burk (1953).

RESULTS

Channel catfish were sampled readily from both rivers, while sauger and walleye were taken only from the Missouri River. Sauger and walleye are present in the Niobrara River as documented in a report summarizing a fish kill associated with the flushing of Spencer Hydro (Hesse 1977). Although sauger and walleye are likely common inhabitants of the Niobrara River, adequate sampling methods have not been devised to collect these species in this shallow, braided stream. This report will detail the life history of channel catfish from the two rivers. Too few sauger and walleye were collected; therefore, study of these species must wait until suitable collection methods are devised.

The Niobrara River warmed faster in the spring and cooled more quickly in the fall (Figure 2) than the Missouri. Monthly variation was greater, and diurnal variation was as much as 6°C (June 1977), while diurnal variation in the Missouri was almost nonexistent.

Hoopnetting the Niobrara and Missouri River

Niobrara River channel catfish were captured by baited hoop nets during September 1976 (1,249 fish for 836 net nights) and April through September 1977 (1,624 fish for 4,292 net nights). Catch per unit effort (CPE) for September 1976 was 1.49, while the overall 1977 CPE was 0.38. The CPE for September 1977 was 5.87 (587 fish for 100 net nights). August and July 1977 proved to be next

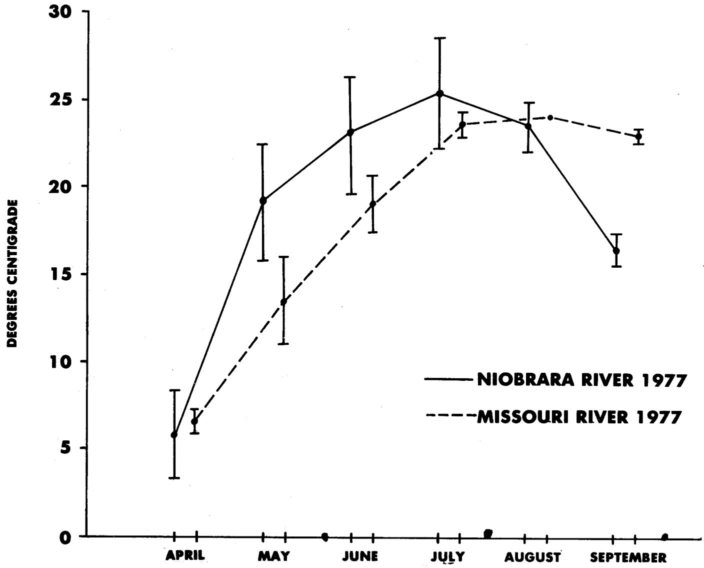

Figure 2. Monthly temperature (°C) variation in the Niobrara and Missouri Rivers, 1977.

best months to capture catfish with CPE's of 5.36 and 1.80 respectively; May 1977 followed at 1.24 (CPE). April and June of 1977 were the slowest months with CPE's of 0.1 and 0.6 respectively.

Hoopnet CPE revealed that the first three km of the Niobrara River support the largest population of channel catfish (834 fish in 480 net nights, CPE = 1.74, data for stations 1 and 2 combined). The region from the tailwaters of Spencer Dam downstream approximately 7 km (stations 5 and 6) supports the next most abundant population demonstrated by a catch of 1,476 fish in 1,680 net nights of effort for a CPE of 0.88. Middle reaches of the river were apparently more sparsely populated. Station 3 and 4 data revealed a sample of 563 fish for 1,353 net nights effort and a CPE of 0.42. The 30 net nights of effort at Station 7 (upstream of dam) yielded four fish for a CPE of 0.13.

Missouri River channel catfish were captured by baited hoop nets during August, September, and October 1976 (373 fish, 1,829 net nights, 0.20 CPE) and April through September 1977 (338 fish, 1,508 net nights, 0.22 CPE). Catch per unit effort was greatest in October 1976 (CPE = 2.33), while CPE was less than 1.0 in 1977 until August when the CPE was 4.70. Monthly differences in CPE between Station 1 (downstream of mouth of Niobrara) and Station 2 (upstream of mouth) indicated a larger population upstream from the Niobrara. This was substantiated by a larger mean CPE for all months and years combined (Station 1, CPE = 0.07; Station 2, CPE = 0.24).

Channel Catfish Life History

Sex ratios did not deviate significantly from 1:1 ($P < .05$, chi--square) in either 1976 or 1977 from the Missouri or Niobrara. All samples did indicate slightly smaller numbers of females.

The mean total length, median and mode of length frequency distributions (Table 1) by year and by river were computed to be:

	Mean Length	Median	Mode	No. Sampled
Niobrara 1976	251 mm	247 mm	221-240 interval	1,249
Niobrara 1977	252 mm	246 mm	221-240 interval	1,628
Missouri 1976	265 mm	262 mm	281-300 interval	373
Missouri 1977	262 mm	256 mm	241-260 interval	338

The following length-weight relationships were derived to aid in computing unknown weights or lengths when one was known:

	Slope B	Y-intercept A	Correlation Coefficient
Niobrara 1976	3.01	0.0000059	0.984
Niobrara 1977	3.20	0.0000021	0.991
Missouri 1976	2.90	0.000012	0.966
Missouri 1977	2.90	0.000012	0.973

Table 1. Length frequency distributions by 20 mm interval for channel catfish from 1976-1977, Niobrara and Missouri Rivers, Nebraska.

Class Interval	Niobrara 1976	Niobrara 1977	Missouri 1976	Missouri 1977
1-20	0	0	0	0
21-40	0	0	0	0
41-60	4	0	0	0
61-80	5	0	0	0
81-100	1	0	0	0
101-120	2	1	0	0
121-140	1	0	0	1
141-160	8	0	4	9
161-180	63	47	9	12
181-200	133	165	35	20
201-220	144	247	44	33
221-240	199	277	47	52
241-260	198	275	44	53
261-280	143	226	47	38
281-300	113	135	48	40
301-320	95	92	37	31
321-340	60	61	30	14
341-360	35	31	13	14
361-380	22	26	6	8
381-400	6	10	0	9
401-420	6	12	3	1
421-440	2	11	1	1
441-460	1	4	3	0
461-480	3	3	1	0
481-500	0	2	0	1
501-520	1	0	0	1
521-540	1	0	0	0
541-560	0	1	0	0
561-580	1	1	0	0
581-600	0	1	0	0
601-620	1	0	0	0
621-640	1	0	0	0
641-660	0	0	0	0
661-680	0	0	0	0
681-700	0	0	0	0
701-720	0	0	1	0

The unknown weight or length can be computed by substitution in the following equation: Weight = A X Length^B.

Coefficient of condition (KTL) was computed separately for male and female channel catfish. The Missouri and Niobrara samples in 1976 and the Missouri sample in 1977 were not found to have significantly different ($P < .05$) mean KTL values for males and females. The mean KTL's for males and females for 1977 Niobrara River channel catfish were significantly different ($P < .01$). The mean KTL and standard deviation for male and female catfish in this sample were 0.6626 ± 0.1108 and 0.6539 ± 0.0920 respectively.

Channel catfish sampled from the Missouri River were in better condition when compared monthly with those from the Niobrara (Table 2). Only the May and June differences were significant at the 95% level, and the August differences were significant at the 90% level. The difference in mean KTL for September 1976 samples (Missouri 0.7330 ± 0.1208; Niobrara 0.6342 ± 0.1291) were not significant but the better conditioned fish were still found in the Missouri River.

The monthly differences in body condition of Niobrara River channel catfish proved to be significant ($P < .05$) when a monthly KTL was compared with the previous monthly KTL. The greatest deviation occurred between April, May, and June and probably indicates the channelization of energy into gamete production. This same significant relationship between monthly samples of Missouri River fish could not be demonstrated, but there appears to be a change in body condition between April, May, and June also.

Older fish appeared to be in poorer condition in the Niobrara River (Table 3), yet a significant difference ($P < .05$) was demonstrated only between age classes six and seven and in this instance age seven fish were in better condition than age six. The sample of age seven fish were much smaller, though. No trend was evident in Missouri River catfish, although the differences between age class two and three and three and four were significant ($P < .05$). Mean age class condition was compared in an F-test between Niobrara and Missouri River samples; the differences at age two and age three were significant ($P < .05$). All other age class comparisons were insignificant, although differences suggest poorer conditioned fish inhabiting the Niobrara.

Niobrara channel catfish captured in 1976 were represented by 10 age classes. Mean yearly growth for the previous 10 years was found to be 63 mm in total length (Table 4). Growth in length was best early in their lives and declined slowly to age six, while weight gain increased in magnitude with each succeeding year. Mean yearly weight increase was 153 grams. Ten year-classes were also captured in 1977 (Table 5). Mean yearly length increase was computed to be 35 mm, while mean weight increase was found to be 60 grams.

Table 2. Monthly condition factors (KTL) for channel catfish captured in 1977 in the Niobrara and Missouri Rivers, Nebraska.

Niobrara River

	April	May	June	July	August	Sept.
Mean	0.7039	0.5924	0.6916	0.6881	0.6386	0.6825
Standard Deviation	0.0	0.0832	0.0965	0.1282	0.0894	0.1069
Coefficient of Variation	0.0	14.0462	13.9537	18.6328	14.0020	15.6642
Standard Error	0.0	0.0080	0.0058	0.0120	0.0039	0.0044
Mean Square	0.0	0.0069	0.0093	0.0164	0.0080	0.0014
Degrees of Freedom	0	107	278	113	533	584

Missouri River

	April	May	June	July	August	Sept.
Mean	0.7369	0.7275	0.7096	0.7015	0.7007	0.7131
Standard Deviation	0.1335	0.1651	0.1374	0.0487	0.0846	0.1069
Coefficient of Variation	18.1226	22.6930	19.3672	6.9463	12.0751	14.9928
Standard Error	0.0252	0.0584	0.0414	0.0126	0.0059	0.0128
Mean Square	0.0178	0.0273	0.0189	0.0024	0.0072	0.0114
Degrees of Freedom	26	6	9	13	204	68

Table 3. Condition factors (KTL) partitioned by age class for channel catfish captured in 1977 in the Niobrara and Missouri Rivers, Nebraska.

	Niobrara River Age Classes					
	2	3	4	5	6	7
Mean	0.6718	0.6701	0.6522	0.6525	0.6496	0.7343
Standard Deviation	0.0624	0.0291	0.0830	0.1171	0.0986	0.0907
Coefficient of Variation	9.2877	19.2692	12.7297	17.9404	15.1791	12.3514
Standard Error	0.0147	0.0116	0.0053	0.0098	0.0095	0.0214
Mean Square	0.0039	0.0167	0.0069	0.0137	0.0097	0.0082
Degrees of Freedom	16	122	242	141	106	16

	Missouri River Age Classes					
	2	3	4	5	6	7
Mean	0.7231	0.6738	0.7090	0.7288	0.7163	0.7883
Standard Deviation	0.1095	0.0681	0.0885	0.0974	0.0935	0.1196
Coefficient of Variation	15.1443	10.1067	12.4759	13.3602	13.0576	15.1745
Standard Error	0.0104	0.0079	0.0111	0.0203	0.0270	0.0598
Mean Square	0.0120	0.0046	0.0078	0.0095	0.0087	0.0143
Degrees of Freedom	108	73	61	21	10	2

Table 4. Channel catfish growth backcalculated from pectoral spine sections; Niobrara River, 1976; total length in mm, weight in grams.

		Mean Total Length at Formation of Annulus									
Age	N	I	II	III	IV	V	VI	VII	VIII	IX	X
1	8	38									
2	12	32	128								
3	11	45	125	203							
4	14	100	108	180	231						
5	18	7	112	168	221	281					
6	6	0	87	172	228	278	331				
7	4	0	107	198	257	297	223	395			
8	1	0	113	253	333	390	433	475	519		
9	0	0	0	0	0	0	0	0	0	0	
10	1	0	113	192	253	292	324	374	399	467	510
Total	75										
Number		14	63	53	43	30	12	6	2	1	1
Ave. Calculated Length		47	114	183	231	287	303	405	459	467	510
Increment of Increase			67	68	49	56	16	102	156	8	43
Ave. Weight		29	53	117	207	368	537	944			
Increment of Increase			25	64	90	161	169	407			

Table 5. Channel catfish growth backcalculated from pectoral spine sections; Niobrara River, 1977; total length in mm, weight in grams.

		Mean Total Length at Formation of Annulus									
Age	N	I	II	III	IV	V	VI	VII	VIII	IX	X
1	0	0									
2	18	49	159								
3	124	46	138	205							
4	244	52	134	192	237						
5	143	51	126	174	217	261					
6	108	53	125	189	205	245	291				
7	18	57	121	185	222	248	281	326			
8	1	0	85	143	201	226	232	269	306		
9	1	0	72	156	188	207	238	250	269	293	
10	1	0	91	156	201	258	318	330	342	360	366
Total	658										
Number		385	658	640	516	271	129	21	3	2	1
Ave. Calculated Length		51	132	188	224	253	289	320	305	327	366
Increment of Increase			81	56	36	29	36	31	15	22	39
Ave. Weight		0	74	87	114	144	204	368			
Increment of Increase			13	27	30	60	164				

Mean yearly growth in total length of Missouri River catfish (1976 sample) was 59 mm for 10 age classes (Table 6). Mean weight increase was 105 grams for the same sample. In 1977, mean yearly growth was computed to be 52 mm for seven age classes (1971-1977) (Table 7), while mean weight increase over the period was 87 grams.

For the purpose of statistical comparison of growth in length and weight between Niobrara and Missouri River samples, analysis of variance was performed on empirical length and weight data of aged fishes. Missouri River fish (1976) were longer and heavier than Niobrara river fish for all age classes compared (ages one through six), but only age class two (length) and one and two (weight) were significantly different ($P < 0.05$). In 1977 all Missouri River fishes in the age classes compared (age classes two through seven) were longer and heavier than their counterpart in the Niobrara River. The differences in mean length for age classes three, four, and six were significant ($P < 0.05$). The differences in mean weight for ages three through seven were significant ($P < 0.05$).

Channel catfish larger than 200 mm TL were tagged (1,832 in the Niobrara and 601 in the Missouri). Nineteen Missouri River tagged fish were recaptured, and 115 Niobrara River tagged fish were recaptured. No movement was recorded for 37% (7) of the Missouri recaptures; 5 fish (26%) had moved into the Niobrara, while the remaining 7 fish (37%) had moved either upstream (3 fish) or downstream (4 fish).

Some 60% (69 fish) of the Niobrara tagged catfish were recaptured at the same location; 12% (14 fish) moved into the Missouri River, and 14% (16% fish) moved from upstream into Niobrara River station 1. The remaining 15 (13%) recaptures were returned upstream from the tagging location. One fish (252 mm TL) was tagged in station 1 (Niobrara River), recaptured in station 2 (Missouri River) 16 days later, and then recaptured 246 days later back in station 1 (Niobrara River).

An attempt was made to estimate the population of Niobrara catfish 200 mm TL or larger from the mouth to Spencer Dam based on the Chapman modification of the short form of the Schnabel multiple census estimate (Chapman 1952, Schnabel 1938).

$$N = \frac{\Sigma(C_t M_t)}{R + 1}$$

M_t . . . total marked fish at large at the start of the t th day
C_t . . . total sample taken on day t
R . . . ΣR_t, total recaptures during the experiment
N . . . Population estimate

Approximate 95% confidence intervals were found by considering R as a Poisson variable (Ricker 1975) in the formula:

$$R + 1.92 \pm 1.960 \sqrt{R+1.0}$$

Table 6. **Channel catfish growth backcalculated from pectoral spine sections; Missouri River, 1976; total length in mm, weight in grams.**

		Mean Total Length at Formation of Annulus									
Age	N	I	II	III	IV	V	VI	VII	VIII	IX	X
1	5	62									
2	31	63	145								
3	26	60	116	222							
4	19	47	116	178	243						
5	15	60	106	184	233	293					
6	3	0	98	166	216	256	306				
7	1	0	67	153	212	258	284	304			
8	0	0	0	0	0	0	0	0	0		
9	0	0	0	0	0	0	0	0	0	0	
10	1	0	127	277	336	408	440	479	518	563	589
Total	101										
Number		12	93	63	38	19	5	2	1	1	1
Ave. Calculated Length		60	123	197	239	291	328	391	518	563	589
Increment of Increase			63	74	42	52	37	63	127	45	26
Ave. Weight		47	83	183	235	376	572				
Increment of Increase			36	100	52	141	196				

Table 7. Channel catfish growth backcalculated from pectoral spine sections; Missouri River, 1977, total length in mm, weight in grams.

		Mean Total Length at Formation of Annulus									
Age	N	I	II	III	IV	V	VI	VII	VIII	IX	X
1	0	0									
2	110	40	150								
3	75	39	132	202							
4	63	47	108	187	248						
5	23	49	115	172	220	272					
6	12	39	91	164	203	261	306				
7	4	0	132	201	251	281	317	352			
Total	287										
Number		134	287	177	102	39	16	4			
Ave. Calculated Length		41	130	190	236	269	308	352			
Increment of Increase			89	60	46	33	39	44			
Ave. Weight		0	76	118	211	257	389	509			
Increment of Increase				42	93	46	132	120			

The population was estimated to be 22,413 + 27,581 - 18,044. The wide intervals were likely associated with the small number of marked fish at large (1,560) and the low percent of recapture (5%). There was a strongly skewed return of tags indicating slow redistribution after tagging. A longer period of mark and recapture may have narrowed the limits of confidence.

Mortality and survival estimates were made from age composition (Table 8) and mark-recapture data (Ricker 1958). The 1976 and 1977 Missouri River samples represented all but the youngest and oldest age classes.

Niobrara sampling produced insufficient numbers of ages one through four to compute mortality based on percentage composition within age classes. Niobrara River mark-recapture data were used to estimate survival(s), total annual mortality (a), annual rate of fishing mortality (m), instantaneous total mortality (i), and instantaneous fishing mortality (p) after Ricker (1958), where marking was done in two consecutive seasons and the rate of survival was assumed to be variable. The time periods established were Period 1 — September 1, 1976 through April 30, 1977; and Period 2 — May 1, 1977, through November 30, 1977. Period 1 represents the fall, winter, and early spring fishery; the data follows: $s_1 = 0.7986$; $a_1 = 0.2014$; $m_1 = 0.0017$; $i_1 = 0.2245$; $p_1 = 0.0045$. Period 2 represents the late spring, summer, and fall fishery; the data follows: $s_2 = 0.7866$; $a_2 = 0.2134$; $m_2 = 0.0167$; $i_2 = 0.2400$; $p_2 = 0.0200$.

The annual rate of survival is high and only a small portion of annual mortality can be attributed to sport harvest.

Food Habits

Channel catfish were sampled from both rivers by baited hoopnets and with an explosive in the Niobrara. Only the explosive acquired samples were used for food habit investigation, therefore food habit data is only available for the Niobrara River population (Table 9). A total of 310 stomachs was analyzed of which 280 (90.3%) contained food items. Age 0 and yearling fish were well represented, with declining samples to age 10.

Aquatic insects were the most abundant item consumed by Niobrara catfish. This held true for the smallest as well as the largest catfish sampled. Changes in the aquatic insect communities could likely result in corresponding changes in the channel catfish population. Fish were also consumed by all sizes of catfish but comprised more of the total contents in the larger fish. Aquatic plants were also important to the Niobrara catfish.

Seine Sampling

Seine hauls revealed information on the forage base of both rivers. A standard unit of effort was difficult to achieve so the data are presented as species composition and relative abundance only (Table 10). A total of 3,754 fish was identified from seine samples; 2,882 were from the

Table 8. Total mortality and survival of channel catfish from the Niobrara and Missouri Rivers, Nebraska for 1976 and 1977, based on percentage composition of age classes.

	Niobrara 1976		Niobrara 1977		Missouri 1976		Missouri 1977	
Affected Age Classes	Total Annual Mortality	Survival	Total Annual Mortality	Survival	Total Annual Mortality	Survival	Total Annual Mortality	Survval
! & 2	*	*	*	*	*	*	*	*
2 & 3	*	*	*	*	0.16	0.84	0.32	0.68
3 & 4	*	*	*	*	0.27	0.73	0.16	0.84
4 & 5	*	*	0.41	0.59	0.21	0.79	0.63	0.37
5 & 6	0.67	0.33	0.25	0.75	0.80	0.20	0.48	0.52
6 & 7	0.33	0.67	0.83	0.17	0.67	0.33	0.67	0.33
7 & 8	0.75	0.25	0.94	0.06	*	*	*	*
8 & 9	0.25	0.75	*	*	*	*	*	*

**Insufficient sample size*

Table 9. **Stomach contents of channel catfish captured in the Niobrara River in 1976 & 1977 by 50 mm increments total length.**

	23-50		51-100		101-150		151-200		201-250		251-300		301-350		351-400		451-500		551-600		601-650	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Nematoda	3	4	9	6			1	5														
Nematomorpha							1	5	1	9												
Annelida			4	3	4	15	3	14			1	50			1	25						
Crustacea	1	1	3	2							1	50			1	25						
Insecta	82	100	146	98	25	96	19	91	10	91	2	100	4	100	3	75	1	100	1	100	1	100
Pisces	4	5	12	8	7	27	4	19	1	9	1	50			1	25			1	100		
Aquatic Plants	5	6	6	4	3	12	9	43	2	18	1	50			2	50						
Unidentified Matter	6	7	8	5	6	23	1	5	1	9					1	25						
Total Stomachs Analyzed	90		149		26		21		11		2		4		4		1		1		1	
Total Stomachs Containing Food	82		139		21		19		9		1		3		3		1		1		1	
% Stomachs with Food	91		93		81		91		82		50		75		75		100		100		100	

Total stomachs analyzed 310; Total stomachs containing food items 280; Percent stomachs containing food 90.

Table 10. Species composition and relative abundance of fish taken by seine in the Niobrara and Missouri Rivers, Nebraska. Number of each species in parentheses.

Rank	Niobrara River	% of Total Sample		Missouri	% of Total Sample	
Number 1	Red Shiner	28.6	(825)	Emerald Shiner	62.0	(541)
2	Sand Shiner	14.9	(430)	River Carpsucker	16.4	(143)
3	River Shiner	14.3	(412)	River Shiner	10.2	(89)
4	Emerald Shiner	13.7	(395)	Sand Shiner	5.5	(48)
5	River Carpsucker	11.7	(337)	Bigmouth Shiner	2.1	(18)
6	Bigmouth Shiner	11.0	(318)	Shorthead Redhorse	1.3	(11)
7	Flathead Chub	3.3	(95)	Red Shiner	1.2	(10)
8	Bluegill	.6	(17)	White Bass	.8	(7)
9	Shorthead Redhorse	.5	(13)	Yellow Perch	.3	(3)
10	Largemouth Bass	.4	(11)	Largemouth Bass	.2	(2)
11	Channel Catfish	.3	(9)			
12	Fathead Minnow	.3	(8)			
13	Silver Chub	.1	(4)			
14	Sauger	.1	(2)			
15	Green Sunfish	.1	(2)			
16	Carp	.1	(1)			
17	Plains Minnow	.1	(1)			
18	Black Bullhead	.1	(1)			
19	Stoneroller	.1	(1)			
		Total	2882			872

Niobrara and 872 were from the Missouri. The six most abundant species found in both rivers were the red shiner (*Notropis lutrensis*),, sand shiner (*notropis stramineus*), river shiner (*Notropis blennius*), emerald shiner (*Notropis atherinoides*), bigmouth shiner (*Notropis dorsalis*), and river carpsucker (*Carpiodes carpio*). However, the order of occurrence was slightly different. More total species were represented in the Niobrara (19) than in the Missouri (10). White bass (*Morone chrysops*) and yellow perch (*Perca flavescens*) were found in the Missouri but not in the Niobrara. Additional data on forage fishes is discussed under the explosive sampling.

Plankton-net sampling

Drift samples were taken from both rivers to describe zooplankton and ichthyoplankton compositions. Cladocera and Copepoda were the major zooplankters (Table 11). The Missouri River supports a much larger concentration of zooplankton than the Niobrara, with the greatest numbers occurring in May, then tapering off through summer. Peak zooplankton densities in the Niobrara occurred in June with a major decline in numbers in July. Boesel (1938), Mathur (1971), Bonneau et. al. (1972), and Walburg (I975) determined that microcrustaceans (typically Copepoda and Cladocera) made up from 33% to 80% of the diet of age-0 channel catfish from various rivers and reservoirs throughout the United States. Food habits of Niobrara age-0 fish distinctly lacked zooplankton food items. Young fish were very dependent on aquatic insects from early postlarval stage on.

Larval fish did not appear in the drift of either river until May. The peak month was June when 0.209 fish/m^3 (Niobrara) and 0.044 fish/m^3 (Missouri) were sampled (Table 12). Drifting ichthyoplankton in both rivers were primarily Cyprinidae and Catostomidae. Northern pike (*Esox lucius*), stoneroller (*Campostoma anomalum*), and sauger were found only in the Missouri, while emerald shiner, river shiner, red shiner, fathead minnow (*Pimephales promelas*), and green sunfish (*Lepomis cyanellus*) were found only in the Niobrara drift. The abundant shiners sampled with seines from the Missouri River were likely spawned in the Niobrara River. Likewise sauger and northern pike were probably not produced in the Niobrara.

Explosive Sampling

The six most abundant species sampled with primacord in the Niobrara included four of the top six taken in seine and drift samples. These include red shiner, river shiner, sand shiner, and emerald shiner. Channel catfish were included in the top six from explosive sampling. A total of 2,028 fish was sampled, representing 23 species (Table 13). An effort was made to estimate the population of 18 of the most abundant species between Spencer Dam and the mouth of the Niobrara (Table 14).

The most abundant species taken per unit effort were red shiner, river shiner, channel catfish, and sand shiner. Channel catfish were sampled at a rate of 3.87 per unit effort for all stations combined.

Table 11. Zooplankton (number/cubic meter of water filtered) sampled from the Missouri (MR) and Niobrara (NR) Rivers, 1977. NA means no sample taken.

Taxonomic Group	April		May		June		July		August	
	MR	NR	MR	NR	MR	NR	MR	NR	MR	NR
Copepoda	415	14	1140	21	823	53	396	21	270	NA
Calanoida	371	0	906	15	676	36	328	15	257	NA
Cyclopoida	44	14	234	6	140	17	68	5	12	NA
Unidentified	0	0	0	1	7	1	0	1	0	NA
Cladocera	397	5	3934	48	3312	366	389	73	553	NA
Daphnia	299	2	3614	42	3270	318	306	35	335	NA
Diaphanosoma	0	0	0	0	0	4	73	7	219	NA
Bosmina	0	2	0	2	0	9	0	1	0	NA
Unidentified	98	1	320	4	42	35	10	30	0	NA
Total Zooplankton	812	19	5074	69	4135	419	785	94	823	NA

Table 12. Monthly species composition and numbers of larval fish taken from the Niobrara and Missouri Rivers -- 1977. Group descriptions from Hogue et. al. (1976).

Species	Niobrara River Apr	Niobrara River May	Niobrara River Jun	Niobrara River Jul	Niobrara River Aug	Missouri River Apr	Missouri River May	Missouri River Jun	Missouri River Jul	Missouri River Aug
Esox lucius	0	0	0	0	0	0	0	0	0	0
Campostoma anomalum	0	0	0	0	0	0	1	0	0	0
Notropis atherinoides	0	0	1	0	0	0	0	0	0	0
Notropis blennius	0	0	1	0	0	0	0	0	0	0
Notropis lutrensis	0	0	3	0	0	0	0	0	0	0
Notropis stramineus	0	0	0	1	0	0	0	0	0	2
Pimephales promelas	0	0	1	0	0	0	0	0	0	0
Ictalurus punctatus	0	0	0	1	0	0	0	0	0	0
Lepomis cyanellus	0	0	1	0	0	0	0	0	0	0
Pomoxis nigromaculatus	0	0	7	0	1	0	0	0	1	0
Stizostedion canadense	0	0	0	0	0	0	5	5	0	0
Group A Cyprinidae	0	1	0	0	0	0	0	0	0	0
Group B Cyprinidae	0	1	92	6	2	0	3	6	2	0
Group A Catostomidae	0	3	16	1	0	0	0	31	0	0
Group C Catostomidae	0	5	24	2	0	0	0	114	23	1
Group D Catostomidae	0	0	1	0	0	0	0	4	2	0
Unidentified	0	2	7	0	0	0	0	0	0	0

	Niobrara River Volume Filtered, m^3	Niobrara River Total Fish	Niobrara River Total Species	Niobrara River No. Fish/m^3	Missouri River Volume Filtered, m^3	Missouri River Total Fish	Missouri River Total Species	Missouri River No. Fish/m^3
May	356.4	12	5	0.034	2973.6	9	3	0.003
June	736.2	154	11	0.209	3628.2	161	6	0.044
July	403.7	11	5	0.027	2877.6	28	4	0.010
August	422.0	3	2	0.007	1345.0	3	2	0.002
TOTALS	2103.4	180	14	0.086	12018.7	201	9	0.017

Table 13. Species composition and relative abundance of fish taken from the vegetated bankline and mid-bar habitats of the Niobrara River with primacord.

	Species	% of Total Sample	
1.	Red Shiner	41.6	(845)
2.	River Shiner	16.9	(342)
3.	Channel Catfish	13.8	(279)
4.	Sand Shiner	10.3	(209)
5.	Flathead Chub	3.9	(80)
6.	Emerald Shiner	2.8	(55)
7.	River Carpsucker	2.3	(46)
8.	Green Sunfish	2.0	(40)
9.	Stonecat	1.0	(21)
10.	Bigmouth Shiner	1.0	(21)
11.	Shorthead Redhorse	.9	(19)
12.	Freshwater Drum	.9	(18)
13.	Largemouth Bass	.4	(9)
14.	Plains Minnow	.4	(9)
15.	Bluegill	.4	(7)
16.	Silver Chub	.4	(7)
17.	Creek Chub	.3	(6)
18.	Carp	.2	(4)
19.	Black Bullhead	.2	(3)
20.	Flathead Catfish	.1	(2)
21.	Plains Killifish	.1	(2)
22.	White Crappie	.1	(2)
23.	White Bass	.1	(1)
			Total 2028

Additional sampling between the U.S. Highway 281 bridge and the base of Spencer Dam yielded 9.2 channel catfish per unit effort. The population was estimated to be 10,243 fish within this 6.68 hectare section of river. The bottom there is rock rubble as opposed to shifting sand.

Sampling in station 7 (upstream of the dam) yielded 6.75 channel catfish per unit effort (bankline sample) and 1.0 catfish per unit effort (mid-bar sample). This is the same combined CPE (3.875) as below and yet hoopnetting above the dam yielded smaller numbers of fish than below. Samples are admittedly small because station 7 was added the second year and because low water conditions precluded sampling during part of 1977. Additional investigation is needed to clarify the situation above Spencer Hydro. Confidence intervals (Table 14) are wide due to sampling methodology (i.e., lack of replication). Values are reported here for future comparison to 1978 sampling after study redesign.

Table 14. Population estimate of 18 species of age 0 and yearling fish from the Niobrara River between its mouth and the base of Spencer Dam.

	No. fish/ 15.1 meters Bankline	Population Estimate*	± 80% Confidence Intervals	No. fish/ 0.0006 ha Mid-Bar	Population Estimate**	± 80% Confidence Intervals	Total Population Estimate	± 80% Confidence Interval
Channel catfish	5.1702	25,987	15,732	2.5714	623,822	994,660	649,809	1,010,392
Flathead catfish	0.0426	214	397	0.0			214	397
Stonecat	0.04255	2,139	2,599	0.0714	17,322	49,976	19,461	52,575
Largemouth bass	0.1915	963	1,091	0.0			963	1,091
Bluegill	0.1489	748	804	0.0			748	804
Green sunfish	1.4681	7,379	5,931	0.0			7,379	5,931
Black crappie	0.0426	214	417	0.0			214	417
River carpsucker	0.7234	3,636	2,776	0.7857	190,611	327,510	194,247	330,286
Carp	0.0638	321	467	0.0714	17,322	49,976	17,643	50,443
Shorthead redhorse	0.2979	1,497	1,096	0.3571	86,632	249,879	88,129	250,975
Flathead chub	0.7234	3,636	4,066	3.2857	797,110	984,956	800,746	989,022
Silver chub	0.0426	214	417	0.3571	86,632	162,056	86,846	162,473
Freshwater drum	0.3830	1,925	4,368	0.0			1,925	4,368
Emerald shiner	1.1702	5,882	8,595	0.0714	17,322	60,407	23,204	69,002
River shiner	5.2766	26,522	22,071	6.7143	1,628,889	4,269,517	1,655,411	4,291,588
Sand shiner	4.0851	20,533	20,930	1.2143	294,589	781,172	315,122	802,102
Bigmouth shiner	0.3617	1,818	4,488	0.2857	69,311	241,630	71,129	246,118
Red shiner	17.2340	86,624	52,962	2.250	545,850	841,822	632,474	894,784

* Based on a total of 76.4 km of estimated bankline habitat

** Based on a total of 1455.6 ha of habitable mid-bar environments

In an effort to delimit station differences between samples acquired with explosives, Duncan's new multiple range test (Steel and Torrie 1960) was used to compare catch per unit effort. Significant differences were found for several species. Bluegill were found to prefer stations 5 and 6; green sunfish were more common in station 6; largemouth bass preferred the lower stations (2 and 3), shorthead redhorse, station 5; river carpsucker were associated most commonly with stations 4 and 6; emerald shiner with the lower stations (1, 2), and carp with stations 4 and 5. The abundant shiner species (red, river, sand, bigmouth) were distributed evenly throughout all stations.

The mean length of channel catfish sampled with primacord in June was 28.8 mm TL $\pm$ 8.7 mm (mean $\pm$ SD). For July the mean was 48.3 $\pm$ 12.5; August was 62.8 $\pm$ 10.8; September was 71.6 $\pm$ 10.9. The correlation (r) between body length and month was 0.798 ($p = 0.00001$). Only seven percent of primacord sampled channel catfish were 200 mm TL or larger; most catfish sampled with this method were age-0 fish. Based on the date of first samples of channel catfish postlarvae (June 28, 1977) hatching likely occurred during the first week in June and spawning the last half of May.

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Channel catfish activity in the Niobrara River, as demonstrated by hoopnet catch per unit effort, was greatest during July, August, and September. The greatest numbers appeared to inhabit the first three km of river immediately upstream from the confluence with the Missouri River. There was another area of high density below Spencer Dam for approximately seven km. Middle reaches of the river had a smaller population. Therefore, land acquisition geared to increased catfish harvest should be directed toward the Niobrara State Park area or the vicinity of Spencer Dam.

Catch per unit effort of catfish from the Missouri River was much smaller, and late summer and fall proved to be the months for obtaining channel catfish with baited hoopnets. Within the Missouri River greater numbers of catfish appeared to exist above the mouth of the Niobrara than below.

At the present time channel catfish cannot be net-harvested legally from the unchannelized Missouri River between Lewis and Clark Lake and the Nebraska-South Dakota border. This region of Nebraska is sparsely populated, and personal observation indicated a limited sport fishery. In lieu of actual standing crop estimates, which are unavailable, population density can be compared between the present study area and other sections of the Missouri River where a more extensive sport and commercial fishery exists. We feel catch per net night (CPE) can be utilized to assess density of catfish populations. Hesse et. al. (1976) found that the catch of channel catfish on the channelized Missouri River at Brownville, Nebraska averaged two fish per net night during 1974. Similar CPE was demonstrated for the region of the Missouri in our present study area. When we also consider that the catch from the channelized river represents fish from a much compressed habitat, the CPE values for the unchannelized, where netting locations are more diverse, probably underestimate relative population density. We suggest that the region between the mouth of Bazile Creek upstream to the Nebraska-South Dakota border is a prime candidate for a sport net fishery.

Sex ratio estimation revealed a 1:1 male to female relationship in both rivers.

The mean length of Niobrara catfish was approximately 252 mm TL for both 1976 and 1977, while the mean length of catfish from the Missouri was 12 mm TL greater (264 mm). The poorer quality of life in the Niobrara is further detailed by smaller mean monthly condition factors (KTL). Females from 1977 Niobrara River sampling were also found to be in poorer condition (KTL) than males. Missouri River fish (1976) were found to be longer and heavier than Niobrara River fish (1976) for all age classes compared but only age classes one and two were significantly different. This same relationship was again demonstrated in 1977 with age classes three, four, and six showing significant difference. Niobrara River fish are definitely in poorer overall condition than their Missouri River counterparts.

The Niobrara river warms earlier in the season and diurnal variation is greater than in the Missouri. This should create favorable spawning conditions earlier in the Niobrara allowing a longer period of postlarval development and better condition going into the winter within the Niobrara. Growth information suggests that whatever advantage might be obtained through early hatching is offset by other variables, such as the lack of zooplankton or dewatering conditions due to the operation of Spencer Hydro. This factor coupled with silt flushings probably reduced biomass of aquatic insects a primary food of channel catfish.

Channel catfish were tagged and recaptured in both rivers; 6.3% were recaptured from those tagged in the Niobrara and 3.2% of the Missouri tagged fish were recaptured. Nearly as many of the Missouri tagged fish moved into the Niobrara (26%) as those not moving (37%). The remaining recaptures moved either up or down river within the Missouri. Sixty percent of the Niobrara tagged fish did not move, 12% moved into the Missouri, and 14% moved from upstream stations in the Niobrara to the vicinity of the mouth of the Niobrara.

The population of Niobrara catfish 200 mm TL or larger was estimated to be 22,413. Highly skewed tag returns were felt to be responsible for the wide confidence intervals and a longer duration study with greater sample sizes might be expected to narrow these limits.

Total annual mortality was estimated from percentage composition within age classes and found to vary from 25% to 94% for ages four through nine. Fishing mortality was computed to account for less than one percent of the total mortality. Access to the Niobrara fishery is poor. There is state-owned access at Niobrara State Park near the mouth and leased land at Spencer Dam Wildlife Area just below the Hydro facility. The only other easy access is at the Verdel bridge 24 km upstream from the mouth and at the Lynch Bridge 45 km from the mouth. Fishing at the bridges is limited to either bank and for short distances up and downstream.

Set lines are employed by local landowners to take catfish but are infrequently fished. Evidence suggests a severely underutilized resource. Larger harvests would likely benefit the catfishery by reducing competition for existing food items thereby improving body condition of those remaining. Mayhew (1972) estimated the population of channel catfish in a 32 km section of the Des Moines River to be over 100,000 fish. Annual total mortality rate was estimated to be 42% and of this 10% was attributed to sport fishing. He subjected this fishery to a sustained net exploitation of 20% per year and found that harvest barely exceeded recruitment. Mean total annual mortality of Niobrara catfish stocks was nearly 55% for 1976 and 1977, and only 1% of this can be attributed to sport fishing. The remaining 54% is the segment of all fish mortality which could be exploited by a net fishery and not jeopardize the sport fishery or change the present biomass.

Channel catfish in the Niobrara river depend heavily on aquatic insects, and there is a conspicuous lack of zooplankton in their diet as age-0 fish. Drift samples from the Niobrara revealed low densities of zooplankton in comparison to the Missouri. This may explain the poor growth of Niobrara catfish into early age classes. Postlarvae are required to seek out aquatic insects as a mainstay which requires much greater energy output than feeding on plankters. Turbidity may be the factor limiting plankton populations in the Niobrara. This same factor may also be limiting aquatic insect biomass through the periodic silt flushings by the Spencer Hydro facility. Additional research is suggested into the primary and secondary productivity of the Niobrara as related to existing habitat with the potential for improvement at these levels of the food chain. Increases in primary and secondary productivity coupled with greatly increased harvest by both sport and possibly commercial fishermen could greatly improve the Niobrara fishery.

Information on forage fish obtained from seine and explosive sampling revealed a diversity of cyprinid species. The data suggests that the Niobrara serves an important role in the production of forage for the Missouri River fish stocks. The cyprinid species common to the Missouri River were not prevalent as larvae in Missouri drift samples but were found to be abundant in Niobrara drift samples. The apparent abundance of potential forage species and the slow, braided nature of the Niobrara River makes it a prime candidate for stockings of sauger, walleye, and/or northern pike fingerlings.

Eventual movement back to the Missouri River by these fish is inevitable thereby adding to the quality of the Lewis and Clark-Missouri River fishery. Channel catfish was the only major predator found in the lower Niobrara and forage populations should support additions of another predator such as sauger, walleye, or northerns. Stocking ratios and the influence of these stockings should be determined by field investigation. We have already established a baseline for assessing any predator stocking (i.e., the primacord sampling program). During the course of stocking a primacord sampling program could be initiated to monitor cyprinid stock density for comparison with 1977 and 1978 sampling effort.

Age-0 channel catfish were readily sampled with explosives from the Niobrara. Based on the occurrence of early postlarvae in explosive samples, spawning of channel catfish in the Niobrara was placed from mid to late May.

At present, the Niobrara fishery is valuable, though underutilized. Efforts should be made to improve utilization of existing stocks. More importantly, research should be directed toward improving the aquatic conditions of the Niobrara River which would increase the productive capability of the river. This in turn would provide avenues for improvement of the Missouri River-Lewis and Clark Lake fishery. The scope of work leading to improved aquatic conditions cannot be narrowly defined as a result of this study. More research geared toward identifying avenues of attack should be accomplished. Certainly the alteration of NPPD's operating procedure for Spencer Hydro is an initial need, and a review of the potential impact of Norden Dam must follow closely.

Research biologists prepare a specially-designed drift net for a typical set. The flowmeter in the mouth of the net quantified the ichthyoplankton samples.

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