THE STATUS AND DISTRIBUTION OF THE SICKLEFIN CHUB IN THE MIDDLE MISSOURI RIVER, MONTANA

by

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ABSTRACT

This study examined the status and distribution of the sicklefin chub in the middle Missouri River in Montana. Seining in peripheral zones produced only four sicklefin chub. A trawling technique was developed to sample deep water zones of the river, which significantly increased the number of sicklefin chub sampled (n = 298). Sicklefin chub catch per trawl was as high as 1.28 in Section 3 of the study area. The distribution range above Fort Peck Reservoir was 83.7 km spanning from Cow Island to near CK Creek. Habitat variables in peripheral zones included mean depth of 0.50 m, mean velocity of 0.32 m/s and substrate composition of 34% sand, 16% silt and 50% rock. Habitat variables at successful sicklefin chub catch sites in deep-water zones included mean depth of 3.41 m, mean bottom velocity of 0.58 m/s and substrate composition of 70% sand, 2% silt, 13% rock and 15% mixed material. Sicklefin chub ages 1 through 4 were sampled. Backcalculation was used to validate ages determined by reading scales. Twenty-two gravid females and 11 ripe males were sampled between July 18 and August 16. Probable spawning habitat had water depth of 1.98 m, bottom velocity of 0.58 m/s and rock 2.54-5.05 cm diameter. The youngest fish exhibiting reproductive characteristics were age 2. Total body length ranged from 29 to 109 mm. Simple linear regression analysis indicated a positive relationship between total body length and weight. Condition factor ranged from 0.243 to 0.964. Head measurements were used as a means to differentiate small (< 50 mm) sicklefin chub from small sturgeon chub. Annual monitoring of this population should be conducted by trawling at Knox Bottoms (RM 146.5), Sand Creek (RM 158.9) and Sevenmile Creek (173.5). The findings of this study suggest that additional information should be gathered before listing the sicklefin chub as an endangered species in the middle Missouri River in Montana.

INTRODUCTION

Sicklefin chub (*Macrhybopsis meeki*) have rarely been encountered over the past decade, and are suspected of being in danger of extinction throughout their historic range (Werdon 1993_a). Most observations have been incidental to other research and management endeavors. Like other large river fishes, the decline of the species is thought to be due to channelization, irrigation diversion and mainstem impoundments (Reich and Elsen 1979, Pflieger and Grace 1987, Werdon 1993_a). These changes ultimately affect fish abundance by disrupting the natural hydrograph, reducing turbidity, and reducing organic matter availability (Hesse 1993).

The historic range of the sicklefin chub includes the Missouri River and select tributaries from central Montana to southern Illinois, and parts of the lower Mississippi River. The species is documented as currently being present in Missouri (Pfleiger and Grace 1987), Nebraska (very rare) (Hesse 1993, Larry Hesse, GPRRC Consultants, personal communication, 1994), North Dakota (Fred Rykman, North Dakota Game & Fish, personal communication, 1994) and Montana (Gardner and Stewart 1987, Tews 1994). There are seven additional states within the historic range of the sicklefin chub where the population status is not known (Werdon 1993_a).

Sicklefin chub were first reported in Montana in 1980 in the Missouri River above Fort Peck Reservoir (Gardner and Berg 1980) and subsequently sampled downstream of Fort Peck Dam (Gardner and Stewart 1987, Tews 1994). Prior to this the farthest known upstream distribution was the Little Missouri River in North Dakota (Reich and Elsen 1979).

The sicklefin chub is listed as a Species of Special Concern, class B, by the State of Montana indicating that it occurs in limited numbers and/or habitats, and elimination from this area would be at least a moderate loss to the gene pool (Hunter 1994). The United States Fish & Wildlife Service (USFWS) has designated it a Category 1 Species, meaning there are sufficient scientific data available to support a listing proposal (USFWS 1994). In 1993 the USFWS prepared a status report which recommended field studies in the Wild and Scenic section of the Missouri River in Montana to determine the abundance and distribution of the species. In May 1994 the organization American Rivers petitioned the USFWS for Federal protection of the sicklefin chub under the Endangered Species Act of 1973 (Great Falls Tribune, July 1994). Following the filing of the petition, this study was initiated in the Missouri River above Fort Peck Reservoir, which is the longest free flowing section of the Missouri River, to investigate the status and distribution of the sicklefin chub.

The objectives of the study were to: (1) determine the longitudinal distribution and abundance of sicklefin chub within a 160 km reach of the Wild and Scenic River section of the middle Missouri River above Fort Peck Reservoir , (2) determine habitat and species association of sicklefin chub and (3) describe their vital population statistics (length, weight and age).

STUDY AREA

The study area was located in north-central Montana on the middle section of the Missouri River (Figure 1). It consisted of a 160 km reach from the Judith River to the delta area of Fort Peck Reservoir near Beauchamp Creek. The river flows through rugged breaks which are well known for scenic vistas and unique fish and wildlife resources. Recreational use is predominantly canoeing, paddlefish snagging and hunting. The entire length of the study area is protected under Federal law. The first 98 km is classified as National Wild and Scenic River and is administered by the Bureau of Land Management. The lower 77.2 km runs through the Charles M. Russell National Wildlife Refuge and is administered by the U. S. Fish & Wildlife Service. There is a 9.8 km overlap in jurisdiction between the two agencies. The study area was selected because sicklefin chub were known to occur here but little was known about the population status or habitat use (Gardner and Berg 1982).

The middle Missouri River is influenced by nine upstream impoundments and by Fort Peck Reservoir in its downstream reach. This is the longest free flowing stretch of the Missouri River mainstem, and is the least modified throughout the drainage (Berg 1981). This section of the basin drains roughly 110, 000 km^2 . The stream gradient is approximately 0.7 m/km throughout the study area (Berg 1981).

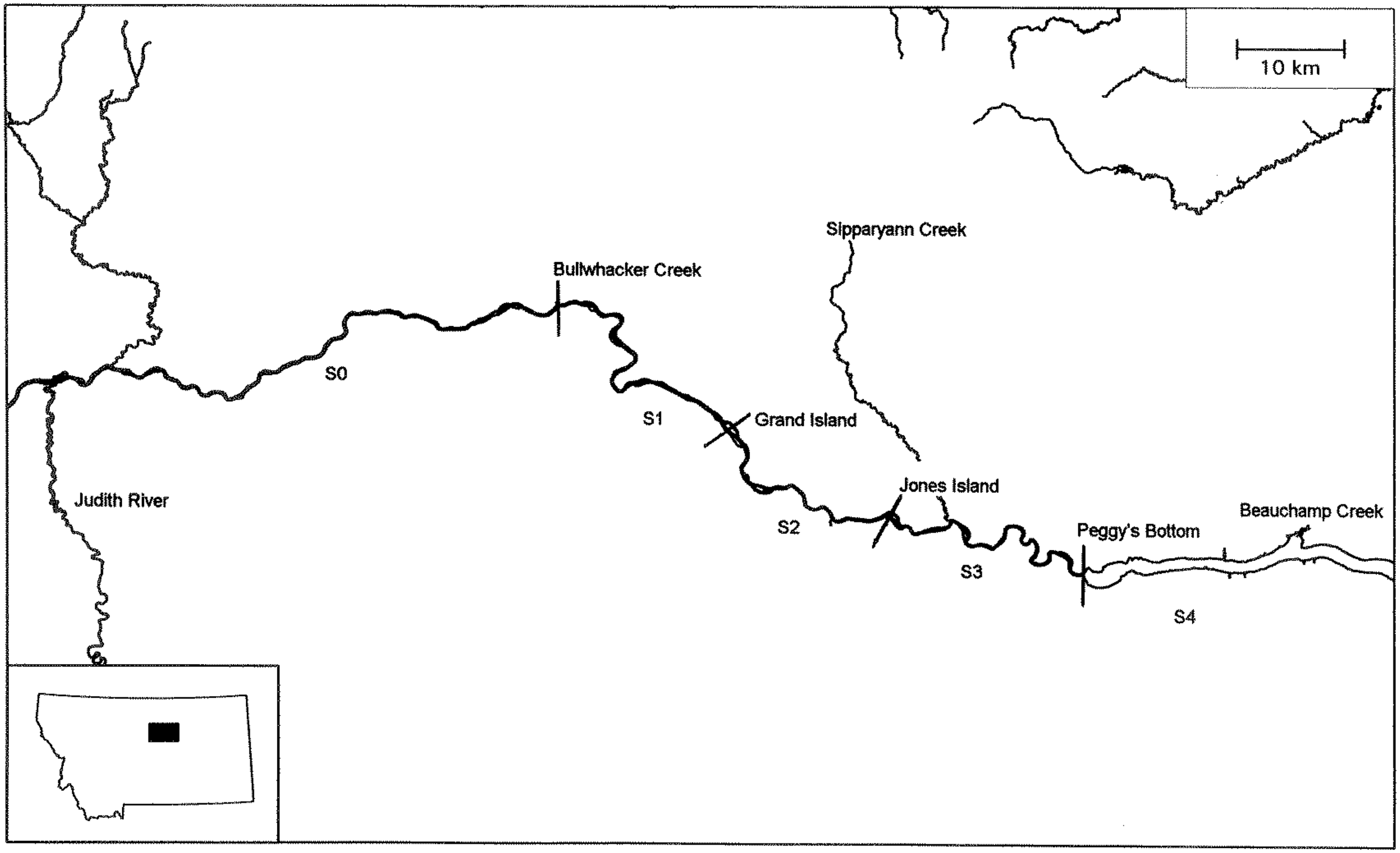

Figure 1. Map of the study area, middle Missouri River, Montana.

The study area was divided into five longitudinal sections based on differences in channel morphology and associated physical characteristics (Figure 1). Section 0 spanned 54.7 km beginning near the Judith River confluence (RM 88) and continuing to near Bullwhacker Creek (RM 122). The channel is very stable, substrate is predominantly large rock with some areas of gravel, and depths are generally less than 2.4 m. Section 1 marked the uppermost known range of the sicklefin chub. It spanned 27.9 km between Bullwhacker Creek (RM 122.1) and Grand Island (RM 139.5). The channel is well defined and armored. Substrate is predominantly gravel with some areas of large rock. Depths are generally no greater than 2.4 m. One significant geologic feature is present near the middle of Section 1. A gradual transition of subterranean parent material occurs between the Eagle Creek sandstone and Bear Paw shale formations resulting in downstream decrease in gradient, finer channel substrate and widening of the floodplain. Section 2 spanned 21.6 km beginning at Grand Island (RM 139.6) and continued down to Jones Island (RM 153). The channel meanders and has point bars, cut banks and numerous shifting island complexes. Predominant substrata appear as intermittent areas of gravel and sand. Depths are generally no greater than 6.7 m. Section 3 spanned 18.8 km beginning at Jones Island (RM 153.1) and continued down to Peggy's Bottom (RM 171.9). The channel is very dynamic and meanders throughout the entire floodplain. Cut banks and point bars are common throughout with some islands present. Substrate is predominantly sand with a few isolated areas of gravel. This section illustrates the impoundment effects of Fort Peck Reservoir and actually lies within its historic delta. Depths are as great as 11.6 m. Section 4 marks the farthest known downstream distribution of sicklefin chub above Fort Peck Reservoir. It spans 24.1 km beginning at Peggy's Bottom (RM 172) and continues downstream to Beauchamp Creek (RM 187). The channel is straight and water velocity is much lower than upstream sections. This section is considered to be the uppermost portion of Fort Peck Reservoir. Substrate is predominantly sand with areas of silt deposition. Depths are generally no greater than 5.5 m. In 1995 the study area was reduced to include only sections 1,2,3 and 4 in an effort to concentrate sampling within the known distribution range of the sicklefin chub. Mean channel width throughout the study area was 197 m (standard deviation (SD) 72.8) and ranged from 76 to 455 m.

METHODS

Fish and Habitat Sampling -1994

The entire study area was divided into 93 1-mile sampling units based on Bureau of Land Management river maps (Bureau of Land Management 1994) which have been used as the standard reference for management and research in the area. Twenty-four units were randomly selected for seining in the peripheral zone of the river in 1994. Ninety-two seine hauls were made throughout 23 of the 24 sites. One site was eliminated, and four others were partially eliminated due to poor seining conditions.

Fish were sampled with a common sense minnow seine (Little et al. 1984). It was 15.2 m long, 1.2 m high and had 6.35 mm mesh with a bottom lead line and a top float line. At each site two seine hauls were made along both banks, one directly above the boat landing, and one directly below. Seining near the boat landing site was not a concern as Paloumpis (1958) illustrated that increased activity in the vicinity of a seining site did not negatively influence catch rates. Two seiners were positioned near each other upstream of the site, each holding half of the net. The procedure began with the two briskly walking away from each other and slightly downstream while deploying the seine perpendicular to the flow as they parted. Seiners moved apart only about 10 m to ensure the seine was forming a bag and walked quickly downstream, slightly faster than the flow of the river. Near the end of the site, the seine was pivoted on the innermost axis and retrieved towards the shore. After each seine haul, length and width of the haul were measured with a 30.5 m tape. Habitat measurements were made at three points along two lateral transects established within the area seined, one at 25% and one at 75% of the distance seined. A Price current meter was used to measure velocity at the three points along each transect. Depth was measured with a top-setting rod to the nearest inch and subsequently converted to metric. Dominant substrate was determined by visual observation or feeling substrate diameter at each point along the transect and assigned a corresponding number code (Table 1).

Fish sampled were enumerated and identified to species with the exception of *Hybognathus spp.* (western silvery/plains minnow) and *Stizostedion spp.* (sauger/walleye) which were difficult to differentiate in the field. Sicklefin chub and sturgeon chub (*Macrhybopsis gelida*) were weighed to the nearest 0.1 g on an Ohaus portable electronic balance and total length was measured in millimeters on a small measuring board. Scale samples were collected from the left side of fish above the lateral line at the mid-point between the nape and dorsal fin and stored in scale envelopes. Pressure was applied to the abdomen of each specimen to document evidence of milt or eggs. Males that released milt were termed ripe and females that had visible signs of eggs in the vent were termed gravid. Following examination specimens were released.

Table 1. Substrate type codes, material description and particle diameter developed for substrate classification.

Code	Material description	Particle diameter (cm)
0	Silt	Silt
1	Sand	Sand
2	Small gravel	0.64-2.54
3	Medium gravel	2.54-5.08
4	Large gravel	5.08-7.62
5	cobble	7.62-15.24
6	boulder	> 15.24

Deep water zones were sampled with a beam trawl, similar to one used successfully to collect juvenile white sturgeon on the Columbia River (Beamesderfer and Nigro 1994). During 1994 trawling techniques were developed and no formal sampling protocol was followed. Rather, I conducted 148 trawls within a 128.72 km reach of river (RM 97 to RM 177) in an effort to describe longitudinal distribution of the sicklefin chub.

The trawl consisted of a metal sled frame measuring 2 m wide by 0.5 m high. The net was 5.5 m long with a 3.8 cm mesh outer chafing net and 3.2 mm mesh inner liner. The cod end was 16.5 cm in diameter. The trawl was equipped with a "rock hopper" lead line having 40 leads and 12 rubber discs to aid in trawling over rock. Three floats were attached to the top of the net to keep the gape open.

The trawl was deployed from a 5.5-m aluminum Wooldridge boat with a 150 horsepower Evinrude outboard jet unit. The boat had a standard electrofishing safety rack on the front. Trawling was conducted from the bow of the boat while traveling downstream in reverse. The trawl was secured to the boat with two, 12.2 m-long, 9.5 mm-diameter braided nylon ropes attached to the base of the shocking rack. A small float with 9.15 m of rope was attached to the crossbar of the trawl to mark its position when in the water.

When the trawl was deployed, a buoy marker was set to identify the upper boundary of the area sampled. The boat engine was accelerated in reverse to 2000 rpm and two technicians deployed the trawl net in the water allowing it to inflate. The entire trawl was then submerged and the ropes were let out evenly to prevent the trawl from turning sideways or flipping. The engine speed was maintained so the boat traveled slightly faster than the flow of the river to keep the net inflated, and generally did not exceed 2500 rpm. When the tow was completed, a second marker buoy was deployed to mark the lower sampling boundary. Boat speed was reduced and the two technicians began retrieving the ropes quickly and evenly to prevent the net from deflating or getting tangled on the sled frame. When the trawl reached the boat, the speed was increased in reverse to prevent the net from drifting under the boat and being drawn into the jet unit. The technicians retrieved the sled frame and net from the water and placed it on the shocking rack. Materials in the net were flushed to the cod end and emptied into a bucket of water.

All fish captured in the trawl were enumerated and identified. Length and weight were recorded, and scales were taken from sicklefin chub larger than 50 mm. Specimens were released with the exception of a few collected for museum purposes.

Depth, substrate and bottom velocity were measured at 25% and 75% of the distance trawled. A Ranging Rangomatic model 1200 range finder was used to measure the distance between the marker buoys. Depth was recorded using an Impulse electronic sonar device mounted to the hull of the boat. A Marsh-McBirney model 201 portable water current meter was used to measure velocity. Three velocity readings were taken from each side of the boat, one near the river bottom, one at 80% depth and a third at 20% depth. An aluminum tube 6.1 m in length was used to probe the river bottom to determine substrate composition (Table 1). This method was tested in areas of known substrate and found to provide accurate description of dominant substrate material.

Fish and Habitat Sampling -1995

Due to the low success of sampling the peripheral zone with a seine in 1994, sampling with a trawl in deep water zones was the primary method used in 1995. The study area for 1995 was reduced to concentrate sampling in areas where sicklefin chub were sampled in 1994. These areas were exclusively within sections 1,2,3 and 4 (RM 128.4 to RM 177.5) (Figure 1). A weighted average of sicklefin catch per trawl haul (CPUE, catch per unit effort), in each section, during 1994, was used to distribute sampling effort in 1995 (Table 2). Given the time allowed for sampling, it was determined that 150 trawls could be conducted, 3 at each of 50 sites. Sections 1,2,3 and 4 were divided into 649 sampling units that corresponded to 0.10 mile increments. A simple random sample without replacement design was used to select the 50 sites using a weighted number of units from each section based on the success in each section in 1994. Due to the low number of units allotted for sections 1 and 4, three units were taken from sections 2 and 3 and added to 1 and 4.

Average distance trawled during the 1994 season was 180 m (68 -366 m) and served as a standard for the procedure. Three 180 m trawls were conducted at each site, one at 25%, 50% and 75% of the channel width. A four sided die was used to randomize the order in which the three would be trawled.

Table 2. Sicklefin chub (SFC) catch per trawl haul (CPUE) by section from 1994 used to assign sampling effort in 1995, middle Missouri River, Montana.

	Distance in km	SFC catch / trawl haul in 1994	% of total catch (84)	# of stations as a % of 50 avail. in 1995	Adjusted # of stations
Section 1	27.9	2/22	2.4	2	5
Section 2	21.6	29/51	34.5	17	14
Section 3	18.8	51/39	60.7	30	27
Section 4	24.1	2/4	2.4	2	5

In 1995 I also sampled upstream of section 0 in an effort to expand the known distribution range of the species. The sites were chosen arbitrarily over 142 km beginning at Fort Benton (RM 1) and continuing downstream to the Judith River (RM 88). Portions of the Teton River were also seined to update historic records.

Temperature and Discharge

A Taylor continuous-recording 30 d thermograph was installed near the middle of the study area directly downstream from the Fred Robinson Bridge. The thermograph was monitored throughout the study by Fish, Wildlife & Parks field personnel. In 1995 the data were compromised when unusually high discharge in June deposited 0.61 m of sand over the probe. Daily "spot" temperature data collected by U.S. Geological Survey field personnel were used as a substitute (USGS 1995_b).

Discharge data were obtained from the United States Geological Survey - Landusky gauging station located at Fred Robinson Bridge (USGS 1994, USGS 1995_a). This station recorded daily minimum, maximum and mean discharge of the river in cubic feet per second. A 25 cm diameter Secchi disc was used daily to measure turbidity at 10:00 a.m.

Age

Sicklefin chub scale samples were processed at Montana Department of Fish, Wildlife & Parks fish aging lab in Bozeman, Montana. Imprints made on acetate sheets were viewed on a Northwest Microfilm model 90 projector at 72 power magnification to determine age. Scales were also used to backcalculate the average length at age.

Fish Identification

Due to similarity of sicklefin and sturgeon chub < 30 mm in total length, preserved specimens were observed under a Bausch & Lomb model ASZ30L2 binocular microscope at 300 power and dissected to remove pharyngeal teeth for species identification (sicklefin 0,4-4,0 sturgeon chub 1,4-4,1). Head length measurements were also used to differentiate small sicklefin and sturgeon chub (Pflieger 1975). For sturgeon chub, distance from snout to eye (a) and distance from eye to rear edge of operculum (b) are nearly equal, whereas with sicklefin chub, measurement (a) is "considerably less" than measurement (b) (Pflieger 1975, p. 102). A random sample of *Hybognathus spp.* was also collected for positive identification in the lab. Specimens were viewed under 40 power magnification with a Bausch & Lomb model ASZ30L2 binocular microscope to remove the head and view the configuration of the basioccipital process. The western silvery minnow (*Hybognathus argyritus*) has a configuration that broadens in a triangular fashion at the posterior end of the process, while the plains minnow (*Hybognathus placitus*) has a uniform rectangular configuration (Gould 1994_b). Positive identification of fathead minnow (*Pimephales promelas*) and lake chub (*Couesius plumbeus*) was made by examining the peritoneum and making scale counts, respectively (Gould 1994_b).

Data Analysis

Statistical analyses were conducted using the Statistical Analysis System (SAS 1991). A Wilcoxon-Mann-Whitney nonparametric rank sum test was used to compare depth and bottom velocity differences between successful sicklefin chub catch sites and unsuccessful catch sites (Conover 1980, Iman 1994). A Kruskal-Wallis non-parametric analysis of variance (ANOVA) test was used to determine if there were significant differences in catch rates of sicklefin chub among the five sections of the study area. Parametric ANOVA was considered in determining significant differences in catch rates with respect to the individual habitat features of depth, substrate and bottom velocity, but lack of homogeneity in variance precluded its use (Neter et al. 1990, Iman 1994). Simple linear regression analysis was used to determine if there was a significant relationship between length and weight of sicklefin chub. It was also used to determine the relationship between habitat variables and catch rates of sicklefin chub in each section. This was done by ordinally arranging the substrate, depth and bottom velocity measurements and regressing catch rates of sicklefin chub with each habitat variable. Backcalculation of growth was conducted using Weisberg's (1989) computer program for analyzing the growth of fish. The Fulton-type index of well being was used to assess condition (weight at length) of the sicklefin chub population (Anderson and Gutreuter 1992). Condition (K) was calculated as follows:

$$K = \frac{W}{L^3} \times 100{,}000$$

where W represents weight, L^3 is the length of the fish cubed and 100,000 is a standard scaling constant. Thirteen length groups having 5 mm intervals were established to provide a more detailed description of sicklefin chub condition.

RESULTS

Discharge and Temperature

During the study period in 1994 (July 6 - August 18) mean river discharge was unusually low at 143.5 m^3/s (5000 cfs) and ranged from 126.2 m^3/s (4460 cfs) to 163.6 m^3/s (5780 cfs). It remained fairly constant during both the seining and trawling surveys (Figure 2). In 1995 peak discharge was more than six times greater. Mean discharge during the sampling period (July 18 - August 31) was 342.2 m^3/s (12,000 cfs), ranging from 246.2 m^3/s (8,700 cfs) to 693.4 m^3/s (24,501 cfs)(Figure 3). On June 8, 1995 discharge reached 905.6 m^3/s (32,000 cfs) which was the greatest discharge experienced in the area for 13 years (Mel White, USGS, Helena, Montana, personal communication, 1996). The 1995 hydrograph had three major peaks over a 3 month period compared to only one major peak in 1994. The most dramatic change occurred in early May 1995 when discharge more than doubled in a 4 d period from 288.7 to 639.6 m^3/s (10,200 cfs to 22,600 cfs).

Mean daily temperature during the sampling period in 1994 was 18.5 °C ranging from 12 °C to 23.5 °C. Mean temperature in 1995 was 21.8 °C ranging from 18 to 28 °C (USGS 1995_b). Mean Secchi reading during 1995 was 27.7 cm

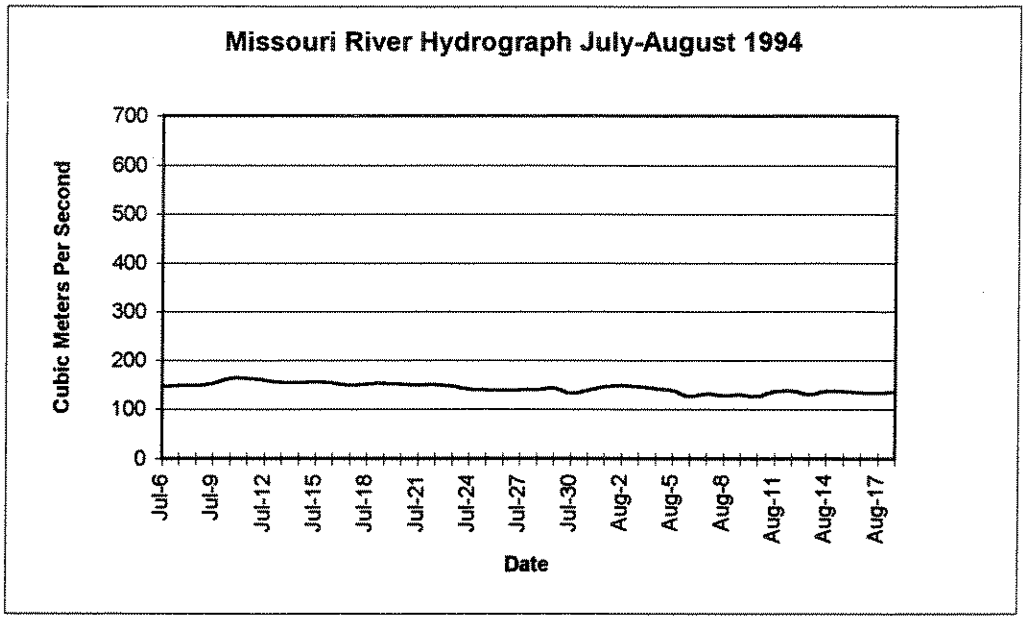

Figure 2. Average daily discharge of the Missouri River measured at the Landusky gauging station during the study period, July 6 -August 18, 1994. (U.S. Geological Survey 1994).

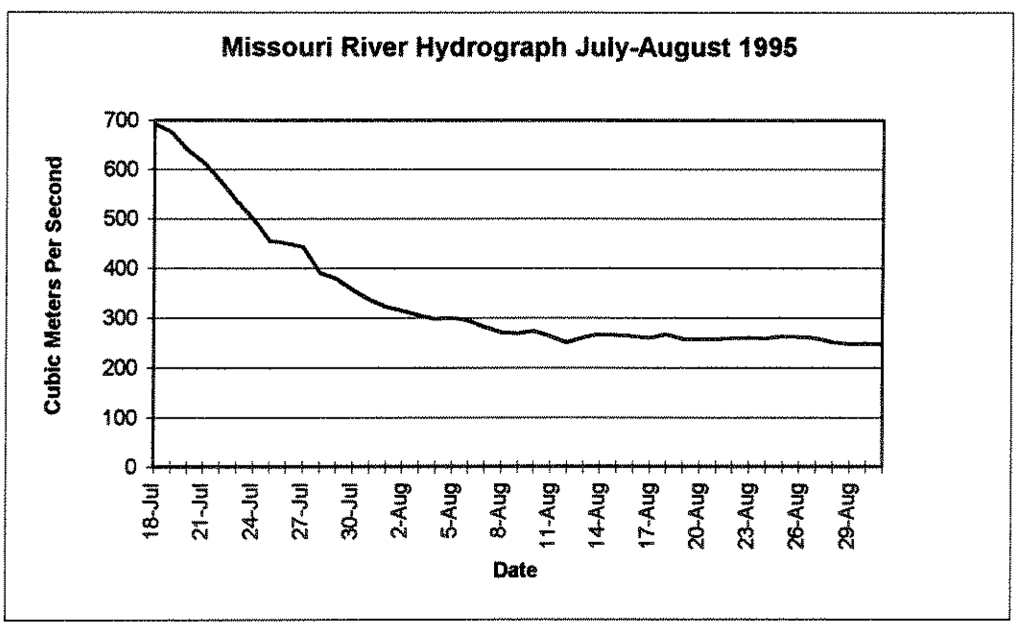

Figure 3. Average daily discharge of the Missouri River measured at the Landusky guaging station during the study period, July 18 -August 31, 1995. (U.S. Geological Survey 1995).

ranging from 10.2 on July 18 to 58.4 cm on August 23, 1995 (SD 13.8).

Fish Abundance and Distribution

I sampled 6,470 fish during the study, representing 30 species from 12 families (Appendix A, Table 14).

Peripheral Zone

I conducted 141 seine hauls throughout the study area during 1994. A total of 5,095 fish representing 23 species was sampled (Table 3). Flathead chub was the most abundant species comprising 45% of the total catch. Only four sicklefin chub (0.08% of total catch) were sampled by seining in 1994; all were in section 1 (Figure 1) at three different sites. Of the 23 species sampled, sicklefin chub ranked 15th in abundance. Average depth at the three capture sites was 0.55 m with a range of 0.41 to 0.75 m. Average velocity was 0.35 m/s ranging from 0.21 to 0.45 m/s. Substrate material consisted of silt, small gravel and medium gravel. Two of the specimens were sampled from a backwater. Mean depth at all seining sites in the peripheral zone was 0.50 m and ranged from 0.19 to 0.86 m (SD 0.15). Mean velocity was 0.32 m/s and ranged from 0 to 0.75 m/s (SD 0.15). Average distance seined was 35.2 m ranging from 10 to 65 m (SD 10.8). Average width was 9.9 m ranging from 7 to 14 m (SD 2.5). The average area covered per seine haul was 348.5 m^2.

Table 3. Fish species composition and abundance from seining both experimental and randomly chosen sites in the middle Missouri River, Montana 1994.

Species	Number	Relative abundance (%)
Flathead chub	2,296	45
Emerald shiner	806	16
Hybognathus spp. (western silvery/plains minnow)	727	14
Carp [a]	410	8
Longnose sucker	227	4
Stizostedion spp. (sauger/walleye) [a]	175	3
Lake chub	169	3
Shorthead redhorse sucker [a]	136	3
Goldeye [a]	41	0.70
Fathead minnow	32	0.63
River carpsucker [a]	23	0.45
Longnose dace	20	0.39
Channel catfish	11	0.22
Sturgeon chub	8	0.16
Sicklefin chub	4	0.08
Yellow perch	3	0.06
Stonecat [a]	3	0.06
Mountain whitefish	1	0.02
Shovelnose sturgeon	1	0.02
Northern pike	1	0.02
Spottail shiner	1	0.02

[a] young-of-the-year of this species sampled

Deep-water zone

There were 324 successful trawls conducted within sections 1,2,3 and 4 during 1994 and 1995. A total of 1,376 fish representing 26 species were sampled (Table 4). In contrast to seining, sicklefin chub was the most abundant species captured in the trawl in 1994 and second most abundant species for both years combined, representing 22% (n = 302) of the total catch. Channel catfish were the most abundant species sampled, making up 30% of the catch. They made up a small proportion of the catch in sections 1 and 2, but dominated the catch in sections 3 and 4. Sicklefin, sturgeon and flathead chubs were the second, third and fourth most abundant species captured with the trawl, respectively.

Sicklefin chub were sampled in 110 (36%) of the trawl sets. Of these, 50 sets had other fish species present (Table 5). Channel catfish were the most abundant species captured with sicklefin chub and comprised 44.9% of the total number of fish sampled. Sturgeon chub and flathead chub were the second and third most abundant species observed at sicklefin chub catch sites, respectively.

Longitudinal Distribution

I documented the longitudinal distribution of sicklefin chub to be 83.7 km beginning near Cow Island (RM 129) and continuing downstream to near CK

Creek (RM 181). I sampled 130 fish representing 10 species in Section 1 (Table 6). The overall CPUE was 3.02 ranging from 1 to 14 fish per trawl. Sturgeon chub was the most abundant species, making up 31% of the total catch with a CPUE of 0.93. Sicklefin chub and longnose dace each made up 24% of the catch with a CPUE of 0.72.

Table 4. Species composition and abundance from trawling in the middle Missouri River, Montana. 1994 & 1995.

Species	Number	Relative Abundance (%)
Channel catfish [a]	406	30.0
Sicklefin chub	302	22.0
Sturgeon chub	260	19.0
Flathead chub	125	9.0
Longnose dace	84	6.0
Stonecat [a]	60	3.0
Shovelnose sturgeon [a]	39	3.0
Carp [a]	19	1.4
Stizostedion spp. (sauger /walleye) [a]	18	1.3
Hybognathus spp. (western silvery/plains minnow)	13	0.9
Longnose sucker	11	0.8
Freshwater drum [a]	8	0.6
Goldeye [a]	5	0.4
Smallmouth buffalo [a]	5	0.4
Shorthead redhorse sucker [a]	5	0.4
White sucker	4	0.3
River carpsucker [a]	4	0.3
Burbot	2	0.2
Fathead minnow	1	0.1
White crappie	1	0.1
Emerald shiner	1	0.1
Mottled sculpin	1	0.1
Bigmouth buffalo	1	0.1
Spottail shiner	1	0.1

[a] young-of-the-year of this species sampled

Table 5. Relative abundance of fish species observed in 50 trawl catches having sicklefin chub present, middle Missouri River, Montana 1994 & 1995.

Species	Number observed	Relative abundance (%)
Channel catfish [a]	184	44.9
Sturgeon chub	78	19.0
Flathead chub	62	15.0
Stizostedion spp. (sauger/walleye) [a]	25	6.1
Shovelnose sturgeon [a]	14	3.3
Hybognathus spp. (western silvery/plains minnow)	11	2.6
Stonecat	10	2.4
Carp [a]	6	1.4
Stonecat [a]	5	1.2
Freshwater drum [a]	4	0.9
Longnose dace [a]	3	0.6
Longnose sucker	3	0.6
White sucker	2	0.4
Shorthead redhorse sucker	2	0.4
Mottled sculpin	1	0.2
Bigmouth buffalo	1	0.2
River carpsucker	1	0.2

[a] young-of-the-year of this species sampled

In Section 2, 209 fish were sampled representing 16 taxa (Table 7). Sturgeon chub was the most abundant species sampled comprising 38.7% of the total catch with a CPUE of 0.81. Sicklefin chub made up 28.2% of the catch with a CPUE of 0.59. Overall CPUE was 2.1 ranging from 1 to 28 fish per trawl.

There were 530 fish sampled in section 3. This section had the highest fish diversity with representatives from 20 species (Table 8). The most abundant was channel catfish, making up 32% of the total catch. Sicklefin chub made up 28.7% of the catch with a CPUE of 1.28. Overall CPUE was 4.49 ranging from 1 to 57 fish per trawl.

Table 6. Species composition, relative abundance and CPUE based on 43 trawls conducted in Section 1, middle Missouri River, Montana, 1994 & 1995.

Species	Number observed	Relative abundance (%)	CPUE (catch/43)
Sturgeon chub	40	31	0.93
Longnose dace	31	24	0.72
Sicklefin chub	31	24	0.72
Stonecat	13	10	0.30
Flathead chub	5	4	0.12
Stizostedion spp. [a]	4	3	0.09
Channel catfish [a]	3	2	0.07
Longnose sucker	2	2	0.04
Mottled sculpin	1	1	0.02

[a] young-of-the-year of this species sampled

In section 4 there were 461 fish sampled representing 19 species (Table 9). Channel catfish were the most abundant species sampled making up 49.2% of the total catch. Sicklefin chub made up only 10.3% of the catch with a CPUE of 0.75. Sturgeon chub were similar in abundance making up 10.5% of the total sample with a CPUE of 0.76. Overall CPUE was 7.2 ranging from 1 to 62 fish per trawl.

Table 7. Species composition, relative abundance and CPUE based on 99 trawls conducted in Section 2, middle Missouri River, Montana, 1994 & 1995.

Species	Number observed	Relative abundance (%)	CPUE (catch/99)
Sturgeon chub	81	38.7	0.81
Sicklefin chub	59	28.2	0.59
Longnose dace	17	7.1	0.17
Stonecat	15	7.1	0.15
Flathead chub	8	3.8	0.08
Channel catfish [a]	8	3.8	0.07
Stizostedion spp. [a]	7	3.3	0.07
Longnose sucker	4	1.9	0.04
Shovelnose sturgeon	3	1.4	0.03
Hybognathus spp.	2	0.9	0.02
White sucker	2	0.9	0.02
Smallmouth buffalo	1	0.4	0.01
Spottail shiner	1	0.4	0.01
Shorthead redhorse sucker [a]	1	0.4	0.01

[a] young-of-the-year of this species sampled

Table 8. Species composition, relative abundance and CPUE based on 118 trawls conducted in Section 3, middle Missouri River, Montana, 1994 & 1995.

Species	Number observed	Relative abundance (%)	CPUE (catch/118)
Channel catfish [a]	171	32.0	1.45
Sicklefin chub	152	28.7	1.28
Sturgeon chub	71	13.4	0.60
Flathead chub	70	13.0	0.59
Stonecat	22	4.1	0.19
Hybognathus spp.	8	1.5	0.07
Shovelnose sturgeon [a]	6	1.1	0.05
Carp [a]	6	1.1	0.05
Longnose dace	5	0.9	0.04
Longnose sucker	4	0.8	0.03
Stizostedion spp. [a]	3	0.6	0.03
Shorthead redhorse sucker	3	0.6	0.03
River carpsucker [a]	3	0.6	0.03
White sucker	2	0.3	0.02
Emerald shiner	1	0.2	0.01
White crappie	1	0.2	0.01
Fathead minnow	1	0.2	0.01
Smallmouth buffalo [a]	1	0.2	0.01

[a] young-of-the-year of this species sampled

Table 9. Species composition, relative abundance and CPUE based on 64 trawls conducted in Section 4, middle Missouri River, Montana, 1994 & 1995.

Species	Number observed	Relative abundance (%)	CPUE (catch/64)
Channel catfish [a]	228	49.2	3.56
Sturgeon chub	49	10.5	0.76
Sicklefin chub	48	10.3	0.75
Flathead chub	34	7.3	0.53
Shovelnose sturgeon [a]	30	6.4	0.47
Longnose dace	16	3.4	0.17
Carp [a]	13	2.8	0.20
Stonecat	10	2.1	0.16
Stizostedion spp.	9	1.9	0.10
Freshwater drum [a]	8	1.7	0.13
Goldeye [a]	5	1.0	0.08
Smallmouth buffalo [a]	3	0.6	0.05
Hybognathus spp.	3	0.6	0.05
Burbot	2	0.4	0.03
Longnose sucker	1	0.2	0.02
River carpsucker [a]	1	0.2	0.02
Bigmouth buffalo	1	0.2	0.02

[a] young-of-the-year of this species sampled

Habitat Associations

Microhabitat preference of sicklefin chub was not attainable due to the large spatial scale of the study and difficulties associated with sampling the large river environment. Seining and trawling did not provide instantaneous collections and sampled such a large area per unit effort that I was unable to determine precisely where fish were captured. Therefore, description of habitat use was general and based on macrohabitat features measured at sicklefin chub catch sites. These data were compared to the habitat features measured at all sample sites combined.

Interpreting substrate data was difficult because multiple substrate types were measured at some sampling sites (Table 10). In deep water zones, 14.1% of the measured substrate was a mixture of silt, sand, gravel, and cobble. An additional 4.5% consisted of varying sizes of rock. Because it was not known which substrate type sicklefin chub were sampled from, observations were consolidated and considered as “mixed substrate material”.

Deep-water Zone

I recorded depth, velocity, and substrate composition at 176 trawl sites. Sand was the most abundant substrate at trawl sites making up 66.4%, silt represented 3.4%, 15.9% was rock including mixed size rock and 14.3 % was a mixture of silt, sand and rock. Sand was the predominant substrate at sicklefin chub catch sites (64.3%). If mixed substrate categories containing sand (10.8) are included (Table 10), 81.1% of sicklefin chub catches were associated with

Table 10. Substrate types (see Table 1) and their relative abundance compared to relative abundance and number of sicklefin chub (SFC) captured at trawl sites, middle Missouri River, Montana. 1995.

Substrate code	# of observations	Relative abundance (%)	# of SFC observed	Relative abundance (%) at SFC catch sites
0	6	3.4	2	1.8
1	117	66.4	72	64.3
2	2	1.7	2	1.8
3	11	5.7	4	3.6
4	4	2.3	1	0.9
5	1	0.6	0	0.0
6	2	1.1	0	0.0
0-1	9	5.1	2	1.8
0-3	2	1.1	13	11.6
1-2	5	2.8	2	1.8
1-3	4	2.3	1	0.9
1-4	2	1.1	3	2.7
1-5	2	1.7	4	3.6
2-3	5	1.7	2	1.8
2-4	1	1.1	3	2.7
4-5	1	0.6	0	0.0
5-6	2	1.1	1	0.9

sand. Comparison of substrate distribution and sicklefin chub catch, by study section, showed an increase in catch densities with increases in sand substrate between sections 1 and 3. This pattern did not hold true for section 4 (Figure 4).

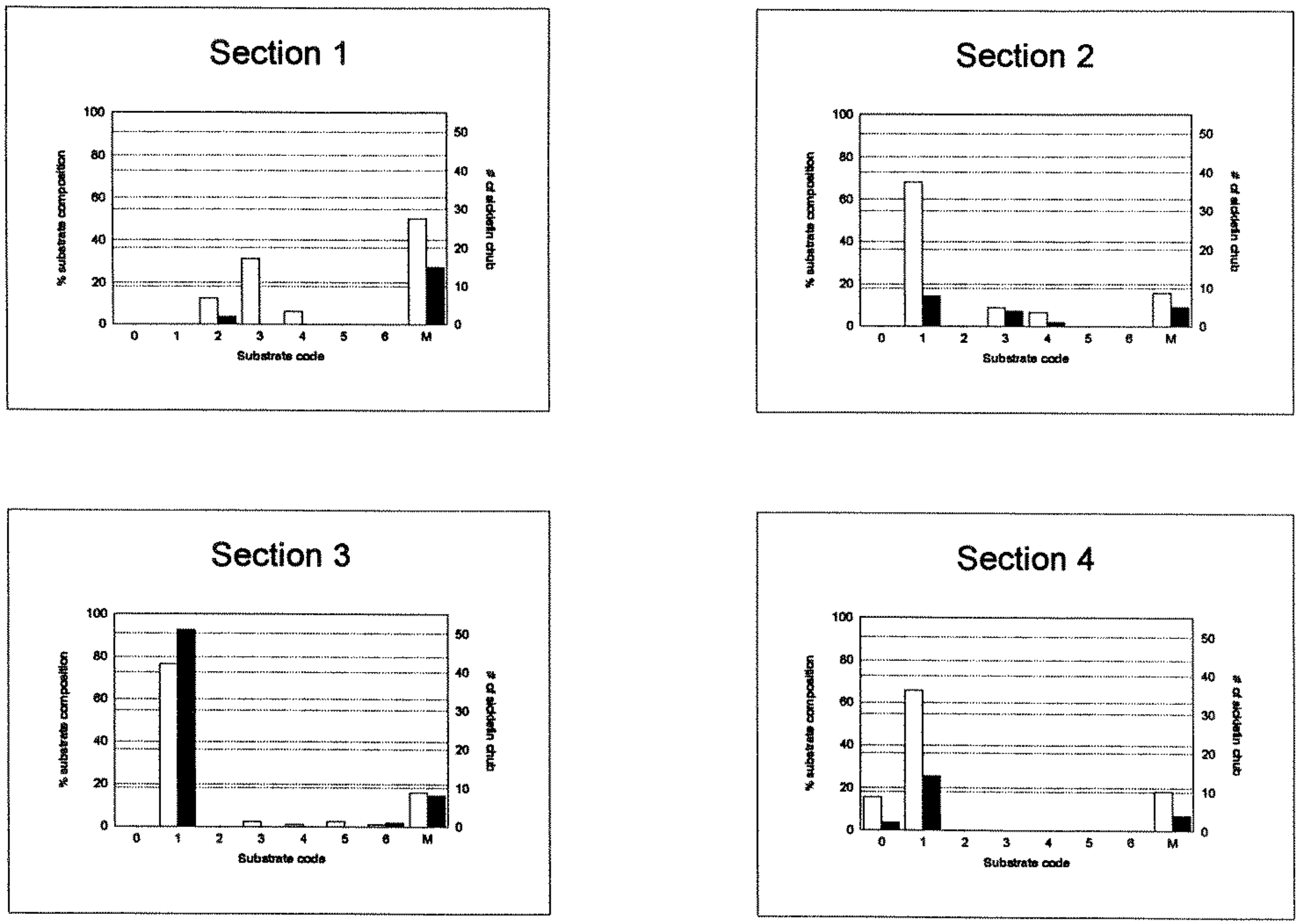

Figure 4. Comparison of substrate composition (see Table 1) at all trawl sites (open bars) with sicklefin chub catch (closed bars) in the four study sections, middle Missouri River Montana. 1995.

Mean depth at all trawl sites was 2.94 m (0.92-6.41) compared to 3.41 m (1.37-6.41) at sicklefin chub catch sites (Table 11). Wilcoxon-Mann-Whitney test results indicated no significant difference ($p = 0.81$). There was also no significant difference observed between sections ($p > 0.24$). No sicklefin chub were sampled at depths < 1.5 m, but only five trawl sets were conducted at shallower depths. Sicklefin chub were present at all depths sampled > 1.5 m. When comparing sicklefin chub catch with depths sampled in each section, no consistent depth association pattern was evident (Figure 5).

Mean bottom velocity at sicklefin chub catch sites was 0.58 m/s (0.32-1.06) and was similar to velocity measured at all trawl sites (mean = 0.61, 0.27-1.12) (Table 11). Wilcoxon-Mann-Whitney test results indicated no significant difference ($p = 0.45$). However, when analyzed by section, a significant difference was observed in Section 3 ($p = 0.05$). Most sicklefin chub were captured in areas with velocities between 0.32 and 0.92 m/s (Figure 6). Although velocities were lower in Section 4, they were within the range associated with maximum catch in Section 3.

Catch per unit effort increased from 0.59 in Section 1 to 0.72, 1.28 and 0.75 in Sections 2,3 and 4, respectively. Catch data were ranked and compared using a Kruskal-Wallis nonparametric ANOVA which indicated no significant difference among sections with respect to catch rates ($p = 0.76$). No habitat variable or combination of habitat variables measured explained the decrease in catch rates between Section 3 and 4.

Table 11. Deep water habitat characteristics at all trawl sites and at sicklefin chub (SFC) catch sites, middle Missouri River, Montana. 1995.

		Section 1	Section 2	Section 3	Section 4	Overall
All sites	Mean depth (m)	1.67	3.14	3.82	3.14	2.94
	Range	0.92-2.59	1.02-5.80	1.22-6.41	1.83-4.60	0.92-6.41
	SD	0.47	1.18	1.35	0.69	3.29
	Mean bottom velocity (m/sec)	0.77	0.63	0.66	0.39	0.61
	Range	0.55-1.01	0.32-1.12	0.37-1.06	0.27-0.65	0.27-1.12
	SD	0.15	0.20	0.14	0.07	0.18
	Substrate (%)					
	Silt	0	0	0	16	3
	Sand	0	67	78	66	66
	Rock	79	22	9	0	16
	Mixed	21	11	13	18	14
SFC sites	Mean depth (m)	1.94	3.23	3.80	3.20	3.41
	Range	1.53-2.29	1.37-5.34	1.98-6.41	2.14-4.58	1.37-6.41
	SD	0.31	1.24	1.24	0.70	1.18
	Mean bottom velocity (m/sec)	0.71	0.64	0.62	0.40	0.58
	Range	0.55-1.00	0.32-0.95	0.37-1.06	0.33-0.55	0.32-1.06
	SD	0.21	0.17	0.16	0.06	0.18
	Substrate (%)					
	Silt	0	0	0	8	2
	Sand	0	54	83	85	70
	Rock	40	38	3	0	13
	Mixed	60	8	14	8	15
SFC	# of adults	31	59	152	48	290
	CPUE	0.59	0.72	1.28	0.75	0.90

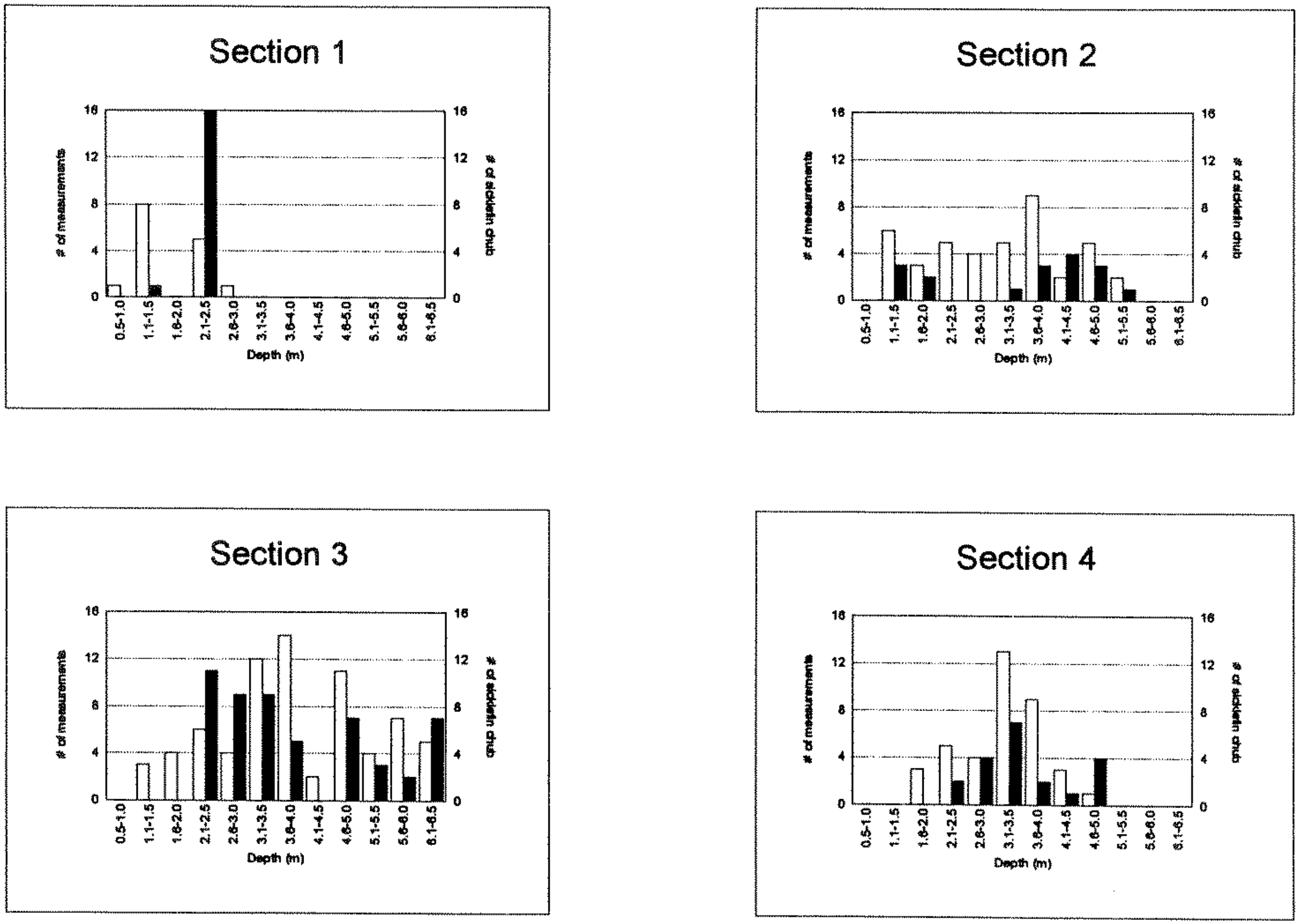

Figure 5. Comparison of depth at all trawl sites (open bars) with sicklefin chub catch (closed bars) in the four study sections, middle Missouri River Montana. 1995.

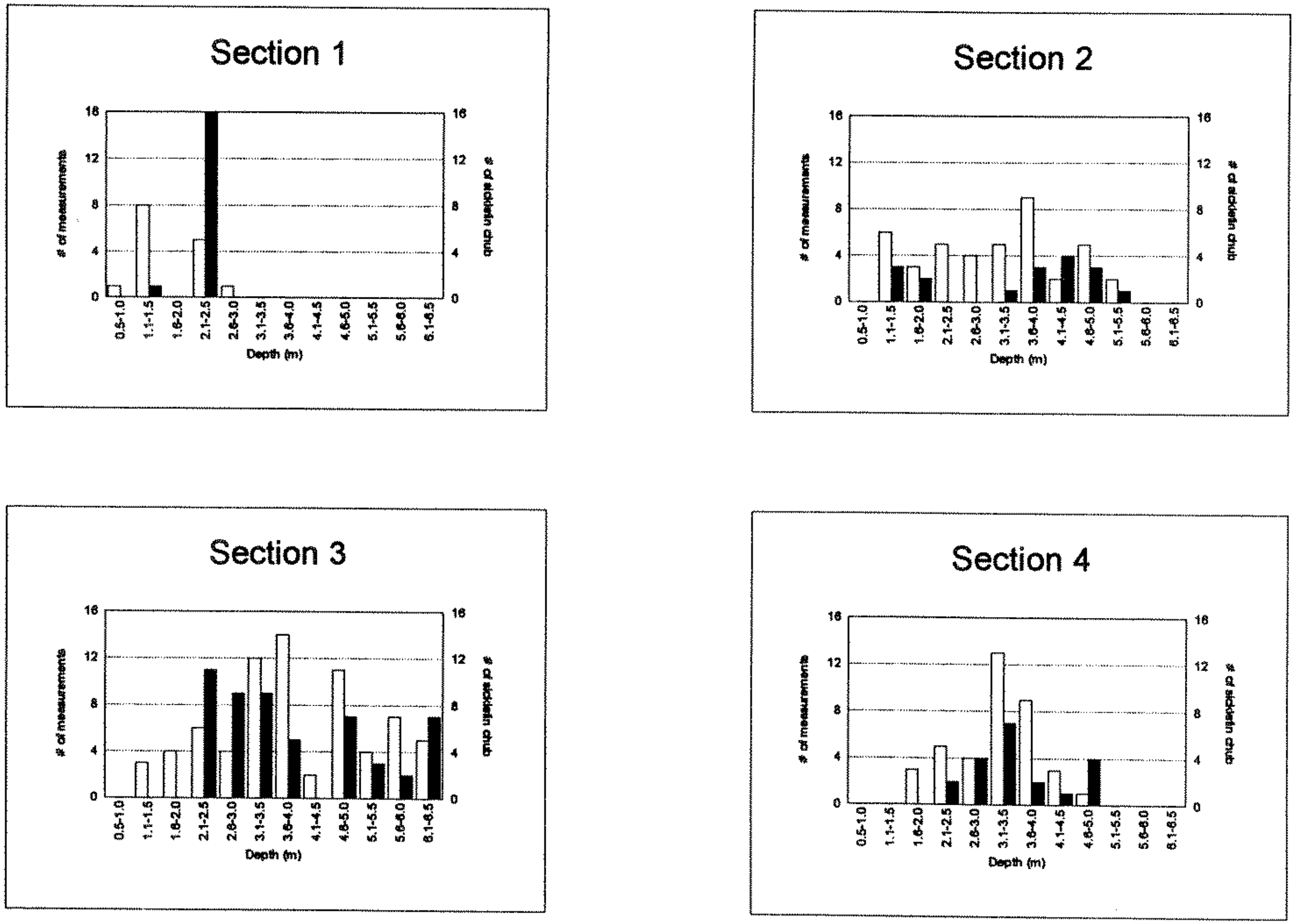

Figure 6. Comparison of bottom velocity at all trawl sites (open bars) with sicklefin chub catch (closed bars) in the four study sections, middle Missouri River Montana. 1995.

Simple linear regression analyses showed no positive relationship between the three habitat variables (depth, substrate or bottom velocity) and sicklefin chub catch rates within or between sections (R^2 < 0.30). Multiple linear regression and logistic regression analyses were not feasible due to problems associated with detectability of sicklefin chub, sampling a large area per unit effort and because the depth, substrate and bottom velocity values for each trawl site were an average of two measurements (Steve Cherry, MSU Statistics Department, Bozeman, personal communication 1996).

The greatest densities of sicklefin chub were in Section 3 which had a CPUE of 1.28. Mean depth measured at all sites in section 3 was 3.82 m ranging from 1.22 to 6.41 m, which was greater than the other sections. Mean bottom velocity at all sites was 0.66 m/s which was similar to the other three sections. A difference was found in substrate composition as sand was measured at 78% of the sites, which was roughly 15% greater than sections 2 and 4 and 100% greater than section 1 (Table 11).

Peripheral Zone

I measured habitat variables at 103 seining sites (Appendix B, Table 15). Substrate composition measured in the peripheral zone was 50% rock, 34% sand and 16% silt. Mean depth measured in peripheral zones throughout the study area was 0.50 m ranging from 0.19 to 0.86 m (SD 0.15). Mean velocity was 0.32 m/s ranging from 0.00 to 0.75 m/s (SD 0.15). Since only four sicklefin chub were sampled from this zone, evaluation of habitat association would not be meaningful.

Length Distribution and Species Identification

Sicklefin chub ranged from 29 to 109 mm total length (Figure 7).Sicklefin chub > 45 mm total length were readily distinguishable from other species by their coloration of cyan-green iridescence on silver. Most individuals had an area of black pigmentation at the junction of the caudal peduncle with the caudal fin. Specimens < 45 mm total length were difficult to distinguish from sturgeon chub. Of the 149 juvenile specimens sampled, 51 were collected to examine pharyngeal teeth. Four fish had counts of 0,4-4,0, which is consistent with the original description for sicklefin chub (Cross 1967). The remaining 47 had counts of 1,4-4,1. Pharyngeal teeth were also extracted from four adult sturgeon chub and three adult sicklefin chub. All specimens had 1,4-4,1 counts. Head measurements were conducted on 22 specimens < 53 mm total length. Thirteen were identified as sicklefin chub and 9 as sturgeon chub. Mean value for measurement (a) (nose to edge of eye) on sicklefin chub was 34.1% (29 -41) less than (b) (eye to operculum) which is "considerably less" . Mean value of (a)

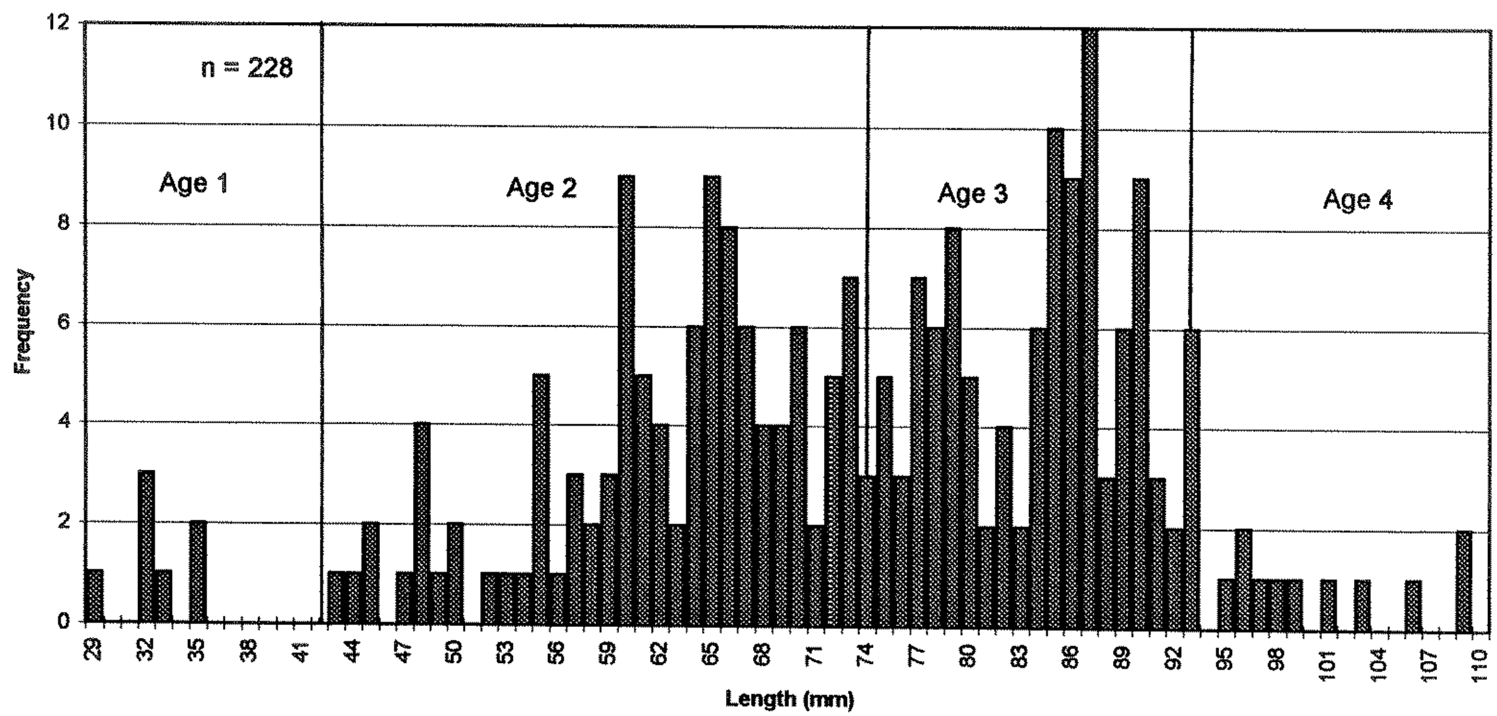

Figure 7. Length frequency and age distribution of sicklefin chub, middle Missouri River Montana. 1994 & 1995.

on sturgeon chub was only 14.3% (8-20) less than (b) which is “about equal”, on a relative scale (Pflieger 1975, p. 102).

Length - Weight Relationship

Weight of sicklefin chub ranged from 0.6 to 9.6 g. The heaviest male weighed 6 g and the heaviest female weighed 9.6 g. However, most specimens weighed between 1 and 6 g.

Sex could be positively identified in only 14% (n = 41) of sicklefin chub sampled. Therefore, all specimens were pooled for condition assessment and length-weight analyses. Mean overall condition value for the sample population was 0.643 ranging from 0.243 to 0.983 (SD 0.106) (Appendix C Table 16). There was little variability in mean condition between length groups (0.509 to 0.691). Simple linear regression analysis of transformed length and weight data indicated a strong positive relationship (R^2 =.906) (Figure 8). The regression model used to estimate mean weight for a given length variable was:

$$(\log)\ \text{weight} = 3.237 \times (\log)\ \text{length} - 5.6398$$

A residual plot of the transformed data indicated that 90% of the observations were within 1 standard deviation of the mean and 99% of the observations were within 2 standard deviations of the mean.

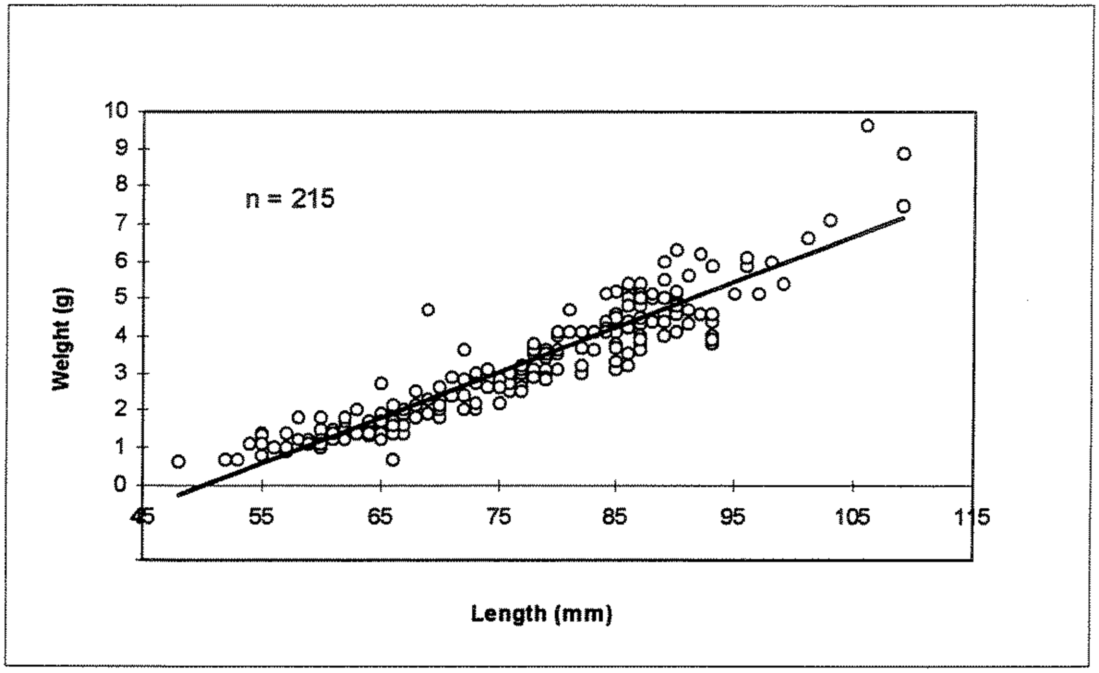

Figure 8. Regression plot of untransformed length and weight variables for sicklefin chub, middle Missouri River, Montana, 1994 & 1995.

Spawning

In 1994 I sampled five gravid female sicklefin chub and one ripe male. These fish were observed between August 5 and 17. Mean discharge during this period was 133.2 m^3/s (126.2 to 138.9) and mean temperature was 21.7 °C (19.7 to 22.7). In 1995, 33 of the sicklefin chub sampled exhibited signs of reproductive readiness, 22 males and 11 females. Gravid females were observed between July 18 and July 31. Mean water temperature during this period was 21.3 °C (20.5 to 22.5) and mean discharge was 507.2 m^3/s (336 to

693 m^3/s). Ripe males were observed between July 19 and August 16. Mean water temperature during this period was 22.3 °C (18 to 28) and mean discharge was 390.1 m^3/s (250 to 676). Pronounced nuptial tubercles were observed on one female and one male near Withrow Bottoms (RM 167) on July 26. Water temperature was 22.5 °C, mean discharge was 450 m^3/s, average depth was 5.43 m, average bottom velocity was 0.70 m/s, and substrate was exclusively sand. Mature males and females ranged from age 2 to 4. In 1995 a "large" concentration of sicklefin chub was observed in the area of "the chimney" (RM 137.5). One trawl set yielded six individuals and another seven. Of the 13 sampled, six were gravid females and one was a ripe male. Mean depth at this site was 1.98 m (1.83 to 2.14) and mean bottom velocity was 0.58 m/s (0.43 to 0.71). Substrate included silt and rock ranging from 2.54 to 5.08 cm in diameter.

Aging

Annuli on sicklefin chub scales were difficult to detect. In most cases scales taken from the largest fish had only about 25 circuli. There was no apparent accretion of circuli which would suggest the formation of an annulus. Anomalies in individual circulus, or differences in growth patterns between one group of circuli and another were interpreted as annuli (Jerald 1992). Mean circuli number between annuli was 3.97 (range 3-5) indicating that most fish formed one circulus approximately every 13 weeks. Scales from 59 of 89 specimens were readable. Blind readings performed by two other readers showed consistency of interpretation. A range of total body length for each age class was established based on scale readings (Table 12). There was little overlap in body length between age classes. The largest fish in the study population were age 4 and ranged from 95 to 109 mm total length. Age three fish ranged from 73 to 93 mm, and age two fish from 43 to 75 mm. Those smaller than 43 mm were considered age 1. Scales from seven fish ranging from 29 to 35 mm total length had between 3 and 4 circuli. Because they were collected in the summer, the focus was considered to be the first years growth and all circuli beyond the focus were interpreted to represent growth in the fish's second year (age 1). The period of greatest growth appeared to be age 2 based on the wide length range observed. Length range for age classes indicated 29% of the sampled population was age 1, 33% age 2, 34% age 3 and 4% were age 4 (Figure 4).

Table 12. Age class structure and length range for sicklefin chub sampled in middle Missouri River, Montana, 1994 & 1995.

Age	Length range (mm)	Number
1	29 - 42	7
2	43 - 75	17
3	73 - 93	25
4	95 -109	10

Backcalculation was used to validate ages determined by scale reading (n = 59)(Table 13). Mean lengths for cohorts fell within the range established from reading scales. Values were reduced by the computer program to reflect length of an age class at the beginning of the growing season (post winter).

Table 13. Length at age by cohort of sicklefin chub determined by scale backcalculation, Middle Missouri River, Montana, 1994 & 1995.

		Cohort			
Age	Length (mm)				
1	Ave	29.45			
	St Dev	2.45			
2	Ave	27.83	63.26		
	St Dev	2.25	3.60		
3	Ave	26.87	61.10	80.29	
	St Dev	2.01	3.47	4.15	
4	Ave	27.61	60.88	78.29	96.31
	St Dev	2.23	3.51	4.15	4.81

DISCUSSION

Sicklefin chub were sampled from below Cow Island (RM 129) in Section 1, to near CK Creek (RM 181) in Section 4 which is 16.9 km farther downstream than previously reported by Gardner and Berg (1982). Absence of sicklefin chub upstream of Cow Island suggests that Cow Island may be the upstream extent of their range. Although trawling was not possible in many upstream areas, I believe the limitations to upstream distribution are probably associated with the change in depth and substrate. Overall, sicklefin chub were sampled over sand 70% of the time. Mean depth at catch sites was 3.41 m whereas in Section 1 and upstream mean depth was less than one half of that (1.67), and there is a general absence of sand upstream of Section 1. No other deepwater habitat data have been reported for sicklefin chub. There is a progressive downstream increase in sand substrate and depth. Significant changes in lateral channel depth in parts of Section 2, all of Section 3 and parts of Section 4, provides great diversity of habitat for this species, a feature that is generally lacking in Sections 0 and 1 of the study area, and upstream.

The near absence of sicklefin chub in my seine catches contrasted sharply with observations by Gardner and Berg (1982), who reported seining 51 sicklefin chub in the same area between Cow Island (RM 122) and Turkey Joe (RM 170.5). Difference in seining technique was not considered important, because Gardner trained the field personnel in my study. Difference in habitat condition between the years, time of sampling or lower sicklefin chub abundance are alternative explanations. The major difference observed between years was discharge. During the same period in 1979 discharge was roughly 350 m^3/s, peaking at 600 m^3/s compared to 143 m^3/s peaking at 163 m^3/s in 1994. Base discharge in 1979 was greater than the peak in 1994. Associated with higher flows in 1979 may have been lower water clarity. If sicklefin chub are negatively phototactic, this would have influenced distribution, as Gould (1994[a]) suggests is true for the sturgeon chub. Temperature data were not available for comparison. Gardner and Berg's (1982) study sampled from late July through early September, which was encompassed by my sampling period.

Fish Sampling

Trawling procedures developed during 1994 facilitated the increase in catch rates of sicklefin chub over seining and served to define the probable distribution of the species above Fort Peck Reservoir. The technique was developed when discharge was 141 m^3/s. In 1995 trawling began on July 18 when discharge was 693 m^3/s, roughly five times greater than the conditions trawled before. Increased discharge did not negatively influence the trawling technique and catch rates of sicklefin chub in deep water zones were similar between years. This suggests the technique may have application in other large river systems with similar or equal discharge.

There was no way to determine whether the trawl was capturing all of the fish in its path of travel. However, I sampled three more species by trawling than by seining (26 vs. 23). Limitations to sampling included trawling over rock > 15 cm in diameter and over silt. However, in a few situations sicklefin chub were sampled over both. In most cases the areas with large rock were avoided due to the destructive effects on the equipment. Only when trawling in the delta area near the extreme lower limits of the study area was difficulty experienced in trawling over silt substrate. Silt was not firm enough to support the trawl and allowed the lead line to dig in and fill the net with silt. Perhaps a more buoyant bottom line would have prevented this. Increased catch rates of sicklefin chub in deep water zones, suggests that siening methods employed in previous studies may have been targeting the wrong habitat zone and thus may not provide an accurate description of sicklefin chub population status. Gardner and Berg's (1982) study area divisions roughly corresponded to dividing my study area in half. Seining CPUE of sicklefin chub in their upper half was 0.89, and 0.50 in the lower half. Similar comparisons with my trawling data show the CPUE in the upper half to be 1.58 and 1.10 in the lower half, which is greater than were reported in 1982.

The area sampled could have affected the difference in results between trawling and seining. During my study, 99,808 m^2 were sampled by trawling compared to 51,926 m^2 sampled by seining. Second, substrate in deep water zones was comprised of 66% sand, 16% rock , 3% silt and 14% mixed (Table 11) compared to peripheral zones which had 34% sand, 50% rock and 16% silt (Appendix B Table 15). Depth was also a major difference. Mean depth in peripheral zones was 0.50 m compared to 2.94 m in deep water zones.

Although sampling techniques employed in 1994 and 1995 were different from past studies in this area, the number of individuals sampled was greater. Perhaps this trend would be seen in the lower Missouri River States if trawling were conducted there as well. Until similar deepwater sampling is conducted in other parts of their historic range, it is difficult to assess how this population compares to others. By virtue of seining more sicklefin chub in peripheral zones in the State of Missouri (Gelwicks 1996), it is possible that deepwater sampling in Missouri would show greater population densities than previously thought. Until such sampling is conducted, this sicklefin chub population appears to be one of the strongest, based on density, throughout the historic range.

Aging

The maximum age of sicklefin chub sampled was 4 years. Backcalculation of length at age supported empirical age interpretation. Backcalculated mean lengths were within the length range of observed fish for all age groups, ruling out Lee's Phenomenon (Busacker et al. 1990). Initially the small fish (< 35 mm) were suspected of being young-of-the-year, but in April 1995 fisheries personnel on the lower Yellowstone River collected several sicklefin chub < 35 mm, indicating that specimens of that size must have overwintered and therefore were age 1 fish (Jim Leibelt, Montana Department of Fish, Wildlife & Parks, Fort Peck, Montana, personal communication, 1995). Carter et al. (1983) also reported specimens collected in Arkansas measuring between 29 and 34 were not young-of-the-year.

Length and Weight

Length and weight relationships calculated for this population provides base-line data for comparison with other populations. Because this study area is the least disturbed of the Missouri River it will provide good comparative data to that collected in the channelized and impounded sections in the lower part of the drainage.

Spawning

Sicklefin chub habitat has been loosely defined (Holton 1990, Werdon 1993$_a$). Due to the difficulty of sampling large rivers it is difficult to obtain a precise description of sicklefin chub habitat requirements (Reich and Elsen 1979). This study attempted to provide base-line data on life history requirements and habitat associations of sicklefin chub. Size and age distribution, as well as presence of gravid females and ripe males indicates successful recruitment over the past 5 years. Pflieger (1975) suggested a spring spawning period based on July collections of young-of-the-year. The spawning period in my study area, based on observations of ripe and gravid fish ranged from July 18 to August 16. Two fish having nuptial tubercles were observed on July 26, 1995. The greatest number of sicklefin chub (7,6,7) captured in individual trawls was observed in a 3-d period between July 31 and August 2, 1995. It is possible that the large number of gravid and ripe sicklefin chub sampled near "the chimney" (RM 137.5) in 1995, were using the 2.5 to 5.0 cm diameter gravel as a spawning substrate. Potential spawning areas might have characteristics similar to this site with depths near 1.9 m and bottom velocities near 0.5 m/s. The youngest fish exhibiting reproductive characteristics were age 2. Gravid females and ripe males were sampled from these groups. There were more age 1 sicklefin chub sampled in 1994 than in 1995, and more gravid and ripe fish observed in 1995 than 1994. The major difference between years was the 2.4 fold increase in discharge in 1995. This environmental cue may be related to the greater number of gravid and ripe sicklefin chub observed in 1995, but is more likely an artifact of sampling. The potential to develop a broodstock and culture techniques for sicklefin chub (Werdon 1993_a) exists since we were able to sample gravid females and ripe males in the study area.

Habitat

Section 3 of the study area had the highest sicklefin chub CPUE at 1.28. Sand was the dominant substrate material measured (78%) and made up a larger percentage of the overall substrate sampled than was observed in the other sections (Table 11). It also had the greatest mean depth overall at 3.82 m. Bottom velocity was similar to the other sections. This suggests that sicklefin chub densities might be greater in areas having greatest depth, predominantly sandy substrate, and bottom velocities near 0.66 m/s. Although 70% of the sicklefin chub were sampled over sand, they also were found over silt and rock. The low abundance of sicklefin chub in the peripheral zone may be related to the near lack of sand there. However, other unmeasured biotic and abiotic factors could have influenced their distribution.

The longest sicklefin chub sampled was 109 mm, which was 7 mm longer than reported by Pflieger (1975) (102 mm).

Identification

The use of pharyngeal tooth counts to differentiate small sicklefin chub from sturgeon chub is unreliable. Harkin (1956), and Bailey and Allum (1962) from Iowa and South Dakota, respectively, reported both species had pharyngeal tooth counts of 1,4-4,1. Robinson reported sicklefin counts of 0,4-4,0 (1988). Cross (1967) reported pahryngeal tooth counts of sicklefin chub in Kansas as 0,4-4,0, and sturgeon chub as 1,4-4,1. In my study 8% of age 1 fish dissected had counts of 0,4-4,0. The remaining 92% had 1,4-4,1 counts. The seven adult specimens examined from both species had 1,4-4,1 counts, indicating pharyngeal tooth counts are not a reliable means of distinguishing between the two species. Head measurements on specimens less than 53 mm in total length was a far better method of differentiation. Nose to eye measurements (a) on sicklefin chub were 34.1% less than the eye to operculum (b) measurements which is "considerably less" (Pflieger 1975, p. 102). Subtle differences were observed on sturgeon chub, as measurement (a) was 14.3% of measurement (b), which is "about equal". It may, however, be difficult to differentiate specimens < 40 mm, using this method, due to lack of precision in making such small measurements.

MANAGEMENT IMPLICATIONS

Based on numbers of fish reported by Werdon (1993_a), this study sampled the greatest number of any reported, with the exception of 888 specimens collected in Missouri over a 43 year period. If this population's status was based solely on seining data, comparison with previous studies (Gardner and Berg 1982) would have indicated a population decline. However, deepwater sampling showed higher densities of sicklefin chub. Recent seining of peripheral zones in Missouri by Gelwicks (1996) produced 163 sicklefin chub. Perhaps deepwater trawling would show greater population densities than is believed based on siening alone.

I recommend that at least three trawls be conducted at three stations annually to assess whether this sicklefin chub population is maintaining itself. Stations that provided a reasonably high probability of capturing sicklefin chub during this study included Knox Bottoms (RM 146.5), Sand Creek (RM 158.9) and Sevenmile Creek (RM 173.5) Such data collections could serve to detect population trends of sicklefin chub.

Based on the findings of this study, additional information should be gathered before listing the sicklefin chub as an endangered species in the middle Missouri River in Montana. Furthermore, deepwater trawling in the lower

Missouri River States should be conducted before further action is taken to list this species as endangered.

APPENDICES

APPENDIX A

(fish species and abundance sampled during study)

Table 14. Species composition and abundance from seining and trawling, middle Missouri River, Montana 1994 & 1995.

Species	Number
Flathead chub (*Platygobio gracilis*)	2421
Emerald shiner (*Notropis antherinoides*)	807
Western silvery minnow (*Hybognathus argyritis*) [b]	740
Plains minnow (*Hybognathus placitus*) [b]	
Carp (*Cyprinus carpio*)	429
Channel catfish (*Ictalarus punctatus*)	417
Longnose sucker (*Catostomus catostomus*)	238
Sicklefin chub (*Macrhybopsis meeki*)	302
Sturgeon chub (*Macrhybopsis gelida*)	268
Walleye pike (*Stizostedion vitreum*) [b]	193
Sauger (*Stizostedion canadense*) [b]	
Lake chub (*Couesius plumbeus*)	169
Shorthead redhorse sucker (*Moxostoma macrolepidotum*)	141
Longnose dace (*Rhinichthyes cataractae*)	104
Stonecat (*Notorus flavus*)	63
Goldeye (*Hiodon alosoides*)	46
Shovelnose sturgeon (*Scaphirhynchus platorynchus*)	40
Fathead minnow (*Pimephales promelas*)	33
River carpsucker (*Carpoides carpio*)	27
Freshwater drum (*Aplodinotus grunniens*)	8
Smallmouth buffalo (*Ictiobus bubalus*)	5
White sucker (*Catostomus commersoni*)	4
Yellow perch (*Perca flavescens*)	3
Burbot (*Lota lota*)	2
Spottail shiner (*Notropis hudsonius*)	2
Mountain whitefish (*Prosopium williamsoni*)	1
Northern pike (*Esox lucius*)	1
Mottled sculpin (*Cottus bairdi*)	1
Bigmouth buffalo (*Ictiobus cyprinellus*)	1
White crappie (*Pomoxis annularis*)	1

[b] both species of this Genera present but not all positively identified

APPENDIX B

(habitat variables in peripheral zones)

Table 15. Habitat variables measured in peripheral zones during seining, middle Missouri River, Montana. 1994.

Variable	Section 0	Section 1	Section 2	Section 3	Section 4	Overall
Mean Depth (m)	0.50	0.49	0.43	0.58	0.56	0.50
Range	0.22 - 0.77	0.21- 0.74	0.19- 0.79	0.31 - 0.86	0.33 -0.41	0.19 -0.86
SD	0.12	0.17	0.16	0.16	0.11	0.15
Mean Velocity (m/sec)	0.34	0.33	0.34	0.29	0.23	0.32
Range	0.10 - 0.64	0.00 - 0.66	0.11 - 0.75	0.14 -0.54	0.15 - 0.29	0.00 -0.75
SD	0.12	0.23	0.16	0.12	0.05	0.15
Substrate (%)						
Sand	8	9	13	77	97	34
Silt	27	24	18	23	3	16
Rock	65	67	69	0	0	50

APPENDIX C

(condition factor statistics for sicklefin chub)

Table 16. Condition factor statistics for sicklefin chub, middle Missouri River, Montana, 1994 & 1995.

Length Group (mm)	N	Weight (g) mean	Weight (g) st dev	Weight (g) range	Condition mean	Condition st dev	Condition range
106-110	3	8.7	1.06	7.5-9.6	0.690	0.113	0.579-0.806
101-105	2	6.8	0.35	6.6-7.1	0.645	0.006	0.640-0.649
96-100	5	5.7	0.43	5.1-6.1	0.621	0.061	0.556-0.689
91-95	12	4.7	0.78	3.8-6.2	0.601	0.105	0.472-0.796
86-90	39	4.6	0.65	3.2-6.3	0.687	0.091	0.503-0.864
81-85	24	4.0	0.56	3.0-5.2	0.691	0.097	0.504-0.884
76-80	28	3.1	0.43	2.5-4.1	0.660	0.074	0.547-0.800
71-75	22	2.5	0.38	2.0-3.6	0.657	0.106	0.514-0.964
66-70	27	1.8	0.37	0.7-2.6	0.597	0.107	0.243-0.795
61-65	26	1.5	0.32	1.2-2.7	0.609	0.112	0.436-0.983
56-60	18	1.2	0.25	0.9-1.8	0.589	0.124	0.462-0.922
51-55	8	1.0	0.26	0.7-1.4	0.636	0.141	0.470-0.841
49	1	NA	NA	0.6	0.509	NA	NA

APPENDIX D

(fish community)

Fish Community

Although designed to investigate the sicklefin chub, this study sampled many other species. Often the health of one species can be used to predict that of the community. The most notable feature of the community structure was the downstream increase in species composition and overall number of fish in sections 1, 2 and 3, which is typical of a healthy riverine system (Allan 1995). Section 4 was found to be a rearing area for at least 7 species (Table 17). Fifty-nine percent of the total catch in Section 4 was comprised of young-of-the-year fish. This rearing area is a 6.4 km reach which is a transitional zone from riverine to lacustrine habitats.

Table 17. Young-of-the-year (YOY) species composition and abundance from seining and trawling in four sections of the study area, middle Missouri River, Montana. 1994 & 1995.

Species YOY	Section 1	Section 2	Section 3	Section 4
Channel catfish	1	7	159	219
Stizostedion spp.	3	14	44	83
Shovelnose sturgeon			1	30
Carp			48	349
Freshwater drum				8
Goldeye				5
Smallmouth buffalo			1	3
River carpsucker			4	18
Goldeye			3	30
Stonecat				1
Shorthead redhorse sucker		1		36

Sicklefin, sturgeon and flathead chubs all have sensitive status at the national level. These three species made up 50% of the overall trawl catch, and flathead chub alone made up 45% of the overall seine catch. This suggests they are not in low abundance as previously thought, at least in the middle Missouri River.

The brassy minnow (*Hybognathus hankinsoni*) was the only species reported in 1982 (Gardner and Berg), that was not encountered during this study. The six important forage species identified by Gardner and Berg (1982) (shorthead redhorse, longnose sucker, flathead chub, emerald shiner, western silvery minnow and longnose dace) were all sampled throughout this study with similar relative densities. Species added to the community assemblage reported in 1982 (Gardner and Berg) included northern pike, white crappie and spottail shiner.

On August 4, 1994 I collected the first young-of-the-year shovelnose sturgeon in Montana by trawling near the Rock Creek boat ramp (RM 163.2). In 1995 an additional 30 were sampled in Section 4 over a 8.85 km reach between Sevenmile Creek (RM 173.5) and CK Creek (RM 179.1). Length of shovelnose sturgeon young-of-the-year ranged from 39 to 70 mm and weight ranged from 0.6 to 2.0 g.

On August 15, 1995 I observed one young-of-the-year paddlefish, approximately 25.4 cm in length, at the water surface near Fisher Coulee (RM 175.6).

Adult sturgeon chub (n = 268) and flathead chub (n = 125) proved to be the third and fourth most abundant species collected in the trawl. Flathead chub populations are decreasing in many parts of the nation. Recent studies on the Missouri River in Missouri sampled only one flathead chub (Gelwicks 1996) and they have been virtually extirpated from the Missouri River in Nebraska (Hesse 1993). Flathead chub was by far the most abundant species observed in the seine during this study, comprising 45% of the total catch (n = 2,296).

The western silvery minnow (*H. argyritis*) and the plains minnow (*H. placitus*) are also species of concern nationally. Recent studies in the state of Missouri sampled only 13 western silvery and 4 plains minnows (Gelwicks 1996), and they are considered very rare in Nebraska with an estimated 96% reduction in abundance (Hesse 1993). The 44 randomly selected specimens of genus *Hybognathus* that I dissected in the lab for positive identification proved to be 23 western silvery and 21 plains minnows which indicates that both species may have similar densities throughout the study area. I sampled 740 *Hybognathus spp.* during this study. This extrapolates to 387 western silvery and 353 plains minnows.

I collected one sand shiner (*Notropis stramineus*) while experimental seining in the Teton River, which extends its westward range by over 402 km (Montana State University, Museum Archives, Bozeman 1996).

Sturgeon chub are Federally listied as a Category 1 species (USFWS 1994), but like the sicklefin chub, do not receive legal protection under the Endangered Species Act of 1973. I sampled 268 throughout the study, 260 by trawling and 8 by seining. The distribution range was found to be 241.8 km spanning from the Virgelle Ferry (RM 38.5) to Beauchamp Bay (RM 182.8). The core habitat, based on CPUE per section consisted of Sections 1 and 2. Sturgeon chub were the most abundant species sampled in these sections. Length ranged from 20 to 100 mm. Weight ranged from 0.6 (47 mm) to 6.9 g (100 mm). The two largest specimens were captured near the Virgelle Ferry during experimental trawling. This observation was 104.6 km upstream from the uppermost collection in my study area.

Sturgeon chub habitat is described as rock substrate (Gelwicks 1996, Gould 1994_a, Stewart 1981), a wide range of depths (Gould 1994_a, Werdon 1993_b), and bottom velocities ranging from 0.11 to 0.36 m/s (Gelwicks 1996). I sampled sturgeon chub over rock substrate 53%, sand 43% and silt 4%. Mean depth at successful sturgeon chub trawl sites was 3.18 m ranging from 1.06 to 6.25 m (SD 1.47), which was slightly less than sicklefin chub (3.41 m). Mean bottom velocity was 0.67 m/s (range 0.35 to 0.99 m/s) (SD 0.16), which was slightly higher than sicklefin chub (0.58 m/s). Sturgeon chub were sampled over rock substrate almost twice as much as sicklefin were. Sturgeon chub occurred in only 22 of 68 sicklefin chub catches (32%), suggesting that sicklefin and sturgeon chub have different habitat requirements. Davis and Miller (1967) found differences in feeding mechanisms which suggests different habitat usage. Observations made during this study tend to support the differences in habitat use for sicklefin and sturgeon chub with respect to depth and substrate. One gravid female sturgeon chub was sampled on September 1, 1995, and one ripe male was sampled on September 16.

My data indicate this community is maintaining itself based on species assemblage and densities of fish compared to past studies (Gardner and Berg 1982). The relatively abundant populations of species of special concern highlights the importance of the middle Missouri River as a reservoir of biological diversity.

APPENDIX E

(sicklefin chub sampling site data)

Table 18. Sampling site data, meristics, comments and age of sicklefin chub, middle Misssouri River, Montana. 1994 & 1995.

1995								1994							
No.	Date	Location	Station (RM)	Length	Weight	Comment	Age	No.	Date	Location	Station (RM)	Length	Weight	Comment	Age
1	18-Jul	LeClair Btms	147.5	106	9.6	Gravid Female		1	14-Jul	Below Cow Isle	129.0	85	4.6		3
2	18-Jul	LeClair Btms	147.5	81	4.7	Gravid Female		2	15-Jul	Power Plant Ruins	134.0	92	4.6		
3	19-Jul	King Isle	151.2	93	5.9	Ripe Male		3	15-Jul	Power Plant Ruins	134.6	90	4.9		3
4	19-Jul	Armells Creek	149.6	86	5.2	Gravid Female		4	27-Jul	Chimney	137.0	87	3.9		3
5	20-Jul	Gardipee Btms	149.9	87	5.4	Gravid Female		5	2-Aug	Jones Isle	152.9	88	4.4		3
6	24-Jul	Tail of Jones Isle	153.9	86	5.4	Gravid Male		6	3-Aug	Below Chimney	137.3	90	4.9		3
7	24-Jul	Tail of Jones Isle	153.9	78	3.5			7	3-Aug	Below Grand Isle	141.1	87	4.8		3
8	24-Jul	Tail of Jones Isle	153.9	86	5.0	Ripe Male		8	3-Aug	Below Grand Isle	141.5	87	4.0		3
9	24-Jul	Tail of Jones Isle	153.9	65	1.4	Female		9	4-Aug	Rock Creek	162.5	101	6.6		4
10	25-Jul	Rock Creek Boat Ramp	162.9	57	1.4			10	4-Aug	Below Swirl Hole	167.0	91	4.3		3
11	25-Jul	Rock Creek	162.0	96	5.9			11	4-Aug	Below Swirl Hole	167.0	87	4.3		
12	25-Jul	Rock Creek	162.0	82	3.7			12	4-Aug	Turkey Joe	170.2	87	4.0		3
13	25-Jul	Johnson Run	160.0	86	4.4	Ripe Male		13	4-Aug	Rock Creek	162.5	86	4.4		3
14	25-Jul	Johnson Run	160.0	84	4.2	Ripe Male		14	4-Aug	Rock Creek	162.5	85	3.1		3
15	25-Jul	Johnson Run	160.0	83	4.1	Ripe Male		15	4-Aug	Below Swirl Hole	167.0	85	3.8		3
16	26-Jul	Below Swirl Hole	167.0	73	3.0	Ripe Male		16	4-Aug	Rcck Creek Boat Ramp	164.2	77	2.8		3
17	26-Jul	Below Swirl Hole	167.0	89	5.5			17	4-Aug	Below Swirl Hole	167.0	75	2.8		2
18	26-Jul	Below Swirl Hole	167.0	87	5.1	Ripe Male/Tubercles		18	4-Aug	Peggy's Bottom	171.1	75	2.6		2
19	26-Jul	Below Swirl Hole	167.0	84	4.4			19	4-Aug	Peggy's Bottom	171.1	70	2.0		2
20	26-Jul	Below Swirl Hole	167.0	78	3.6	Gravid female/Tubercles		20	4-Aug	Rock Creek	162.5	68	2.5		2
21	26-Jul	Below Swirl Hole	166.6	87	5.0			21	4-Aug	Below Swirl Hole	167.0	65	1.6		
22	26-Jul	Below Swirl Hole	166.6	86	3.2	Ripe Male		22	4-Aug	Below swirl Hole	166.3	64	1.6		
23	26-Jul	Below Swirl Hole	166.6	72	3.6			23	4-Aug	Below Swirl Hole	167.0	64	1.5		
24	26-Jul	Below Swirl Hole	166.6	69	2.3			24	4-Aug	Below Swirl Hole	167.0	64	1.4		
25	26-Jul	Rock Creek Boat Ramp	163.2	72	2.8			25	4-Aug	Nichols Coulee	177.5	62	1.5		
26	31-Jul	Bearing Tree	140.9 Exp	74	3.1			26	4-Aug	Below Withrow Btms	168.7	61	1.2		
27	31-Jul	Bearing Tree	140.9 Exp	84	4.2			27	4-Aug	Rock Creek Boat Ramp	164.2	60	1.1		
28	31-Jul	Bearing Tree	140.9 Exp	84	5.1			28	4-Aug	Rock Creek Boat Ramp	164.2	60	1.0		
29	31-Jul	Bearing Tree	140.9 Exp	77	3.1			29	4-Aug	Below Withrow Btms	168.7	60	1.1		
30	31-Jul	Bearing Tree	140.9 Exp	79	3.4			30	4-Aug	Below Swirl Hole	166.3	56	1.0		
31	31-Jul	Bearing Tree	140.9 Exp	73	2.7			31	4-Aug	Below Swirl Hole	167.0	55	1.3		2
32	31-Jul	1 Mile Below Chimney	137.5 Exp	91	5.6	Gravid female		32	4-Aug	Peggy's Bottom	171.1	55	1.1		
33	31-Jul	1 Mile Below Chimney	137.5 Exp	87	4.5			33	4-Aug	Nichols Coulee	177.5	55	1.4		
34	31-Jul	1 Mile Below Chimney	137.5 Exp	67	2.0			34	5-Aug	Slippery Ann Creek	157.3	109	8.9	Gravid F	4
35	31-Jul	1 Mile Below Chimney	137.5 Exp	78	3.8	Gravid female		35	5-Aug	Below Sand Creek	159.5	109	7.5	Spent F	4
36	31-Jul	1 Mile Below Chimney	137.5 Exp	79	3.6			36	5-Aug	Slippery Ann Creek	157.3	103	7.1	Gravid F	4
37	31-Jul	1 Mile Below Chimney	137.5 Exp	80	3.5	Gravid Female		37	5-Aug	Below Sand Creek	159.5	95	5.1		4
38	31-Jul	1 Mile Below Chimney	137.5 Exp	85	4.3			38	5-Aug	Above Sand Creek	157.3	87	3.8		3
39	31-Jul	1 Mile Below Chimney	137.5 Exp	62	1.7			39	5-Aug	Johnson Run	160.0	82	3.0		3
40	31-Jul	1 Mile Below Chimney	137.5 Exp	65	1.9			40	5-Aug	Johnson Run	159.5	79	2.9		3
41	31-Jul	1 Mile Below Chimney	137.5 Exp	80	4.0	Gravid Female		41	5-Aug	Slippery Ann Creek	157.3	73	2.0		2
42	31-Jul	1 Mile Below Chimney	137.5 Exp	78	3.1	Female		42	5-Aug	Below Sand Creek	159.5	72	2.4		
43	31-Jul	1 Mile Below Chimney	137.5 Exp	85	4.2	Ripe Male		43	5-Aug	Below Sand Creek	159.5	60	1.2		

Table 18. Continued.

1995

No.	Date	Location	Station (RM)	Length	Weight	Comment	Age
44	31-Jul	1 Mile Below Chimney	137.5 Exp	65	1.7		
45	31-Jul	1 Mile Below Chimney	137.5 Exp	80	3.6	Gravid Female	
46	1-Aug	2-calf Isle North	144.2	75	2.6		
47	1-Aug	2-calf Isle North	144.2	78	3.1		
48	1-Aug	Above Elk Pasture	154.5	71	2.4		
49	1-Aug	Above Elk Pasture	154.5	64	1.4		
50	1-Aug	Above Elk Pasture	154.5	85	5.2	Ripe Male	
51	1-Aug	Elk Pasture	154.8	90	4.7	Ripe Male	
52	1-Aug	Elk Pasture	154.8	77	3.2		
53	1-Aug	Elk Pasture	154.8	88	4.2	Ripe Male	
54	1-Aug	Elk Pasture	154.8	84	4.2	Ripe Male	
55	1-Aug	Elk Pasture	154.8	89	4.6	Ripe Male	
56	1-Aug	Elk Pasture	154.8	89	5.0		
57	1-Aug	Elk Pasture	154.8	64	1.7		
58	1-Aug	Mauland Ranch	156.8	89	6.0	Ripe Male	
59	1-Aug	Slippery Ann Creek	157.1	85	4.1	Ripe Male	
60	1-Aug	Slippery Ann Creek	157.1	67	2.0		
61	1-Aug	Slippery Ann Creek	157.1	69	1.9		
62	1-Aug	Slippery Ann Creek	157.1	65	1.2		
63	2-Aug	Spike Isle	169.2	66	2.0		
64	2-Aug	Withrow Bottoms	168.0	84	4.1	Ripe Male	
65	2-Aug	Withrow Bottoms	168.0	79	3.1		
66	2-Aug	Withrow Bottoms	168.0	61	1.5		
67	2-Aug	Withrow Bottoms	168.0	80	4.1		
68	2-Aug	Withrow Bottoms	168.0	62	1.8		
69	2-Aug	Withrow Bottoms	168.0	66	0.7		
70	2-Aug	Withrow Bottoms	168.0	90	4.6		
71	2-Aug	Withrow Bottoms	167.3	61	1.4		
72	2-Aug	Withrow Bottoms	167.3	58	1.2		
73	2-Aug	Peggy Btms Islands	172.5	82	3.2		
74	2-Aug	Peggy Btms Islands	172.5	90	4.1		
75	3-Aug	CK Creek	179.1 Exp	53	0.7		
76	3-Aug	Ryan Isle	176.1	48	0.6		
77	3-Aug	CK Creek	179.1	55	0.8		
78	3-Aug	CK Creek	179.1	60	1.2		
79	3-Aug	CK Creek	179.1	52	0.7		
80	8-Aug	Above Sand Creek	158.0	86	4.8		
81	8-Aug	Above Sand Creek	158.0	76	2.5		
82	8-Aug	Sand Creek	158.9 Exp	79	2.9		
83	8-Aug	Sand Creek	158.9 Exp	70	2.3		
84	8-Aug	Sand Creek	158.9 Exp	96	6.1		
85	8-Aug	Sand Creek	158.9 Exp	88	5.0		
86	8-Aug	Sand Creek	158.9 Exp	70	2.0	Ripe Male	

1994

No.	Date	Location	Station (RM)	Length	Weight	Comment	Age
44	5-Aug	Below Sand Creek	159.7	60	1.5		
45	10-Aug	LeClair Bottoms	147.7	99	5.4	Run Milt	4
46	10-Aug	Bell Pool	152.0	93	4.4	Gravid F	4
47	10-Aug	Bell Pool	152.0	93	4.0		
48	10-Aug	Lower 2 Calf Isle	144.6	89	4.0		
49	10-Aug	Below Lower 2 Calf Isle	145.5	86	3.5		3
50	10-Aug	Knox Bottoms	146.7	85	3.7	Gravid F	3
51	10-Aug	Bell Pool	152.0	77	2.6		3
52	10-Aug	LeClair Bottoms	148.0	73	2.2		3
53	10-Aug	Bell Pool	152.0	73	2.2		3
54	10-Aug	Bell Pool	152.0	72	2.0		
55	10-Aug	FRB	148.7	69	1.9		2
56	10-Aug	Below Lower 2 Calf Isle	145.5	68	1.8		2
57	10-Aug	Below Lower 2 Calf Isle	145.5	67	1.6		2
58	10-Aug	Bell Pool	152.0	67	1.9		
59	10-Aug	Bell Pool	152.0	66	1.7		2
60	10-Aug	Bell Pool	152.0	65	1.7		
61	10-Aug	Knox Bottoms	146.7	61	1.2		
62	10-Aug	Bell Pool	152.0	59	1.1		
63	10-Aug	Below Lower 2 Calf Isle	145.5	58	1.8		
64	11-Aug	Below Cow Island	128.4	93	3.8		4
65	12-Aug	Turkey Joe	170.5	75	2.2		3
66	12-Aug	Rock Creek Boat Ramp	163.2	70	1.8		2
67	12-Aug	Below Swirl Hole	166.2	64	1.3		
68	12-Aug	Rock Creek Boat Ramp	163.2	63	1.4		
69	12-Aug	Below Swirl Hole	166.2	57	0.9		
70	12-Aug	Below Swirl Hole	166.2	57	1.0		
71	17-Aug	Elk Pasture	154.9	97	5.1		4
72	17-Aug	Elk Pasture	154.9	85	3.3	Gravid F	3
73	17-Aug	Elk Pasture	154.9	77	3.0		3
74	17-Aug	Duvall Creek	153.1	68	1.8		2
75	17-Aug	Elk Pasture	154.9	68	2.1		2
76	17-Aug	Elk Pasture	154.9	65	1.5		
77	17-Aug	Elk Pasture	154.9	61	1.3		
78	17-Aug	Elk Pasture	154.9	60	1.2		
79	17-Aug	Elk Pasture	154.9	59	1.2		
80	17-Aug	Elk Pasture	154.9	59	1.2		
81	18-Aug	Below Lower 2 Calf Isle	145.6	93	4.6		4
82	18-Aug	Head of Lower 2 Calf Is	143.5	87	3.6		3
83	18-Aug	Head of Lower 2 Calf Is	143.5	74	2.6		2
84	18-Aug	Head of Lower 2 Calf Is	143.5	73	2.7		2
85	18-Aug	Head of Lower 2 Calf Is	143.5	72	2.4		
86	18-Aug	Below Lower 2 Calf Isle	145.6	86	1.6		

Table 18. Continued.

1995								1994							
No.	Date	Location	Station (RM)	Length	Weight	Comment	Age	No.	Date	Location	Station (RM)	Length	Weight	Comment	Age
87	8-Aug	Sand Creek	158.9 Exp	60	1.1			87	18-Aug	Below Lower 2 Calf Isle	145.6	60	1.8		
88	9-Aug	Below CK Creek	181.0	66	2.1			88	5-Aug	Below Sand Creek	159.5	73	2.2		3
89	10-Aug	Sevenmile Creek	173.5 Exp	66	1.4										
90	10-Aug	Sevenmile Creek	173.5 Exp	70	2.6										
91	10-Aug	Sevenmile Creek	173.5 Exp	67	1.4										
92	10-Aug	Sevenmile Creek	173.5 Exp	88	5.1										
93	10-Aug	Fisher Coulee	174.4 Exp	76	2.9										
94	10-Aug	Fisher Coulee	174.4 Exp	54	1.1										
95	10-Aug	Peggy's Btm	171.6 Exp	65	1.7										
96	10-Aug	Peggy's Btm	171.6 Exp	62	1.2										
97	10-Aug	Peggy's Btm	171.6 Exp	80	3.1										
98	11-Aug	FRB	149 Exp	83	3.6										
99	11-Aug	FRB	149 Exp	67	1.6										
100	11-Aug	FRB	149 Exp	66	1.7										
101	11-Aug	FRB	149 Exp	55	1.1										
102	11-Aug	FRB	149 Exp	69	4.7										
103	11-Aug	Knox Bottoms	146.6 Exp	70	2.1										
104	11-Aug	LeClair Btms	148.2 Exp	98	6.0										
105	11-Aug	LeClair Btms	148.2 Exp	89	4.4										
106	11-Aug	LeClair Btms	148.2 Exp	65	2.7										
107	11-Aug	LeClair Btms	148.2 Exp	66	1.6										
108	15-Aug	Below Fisher Coulee	175.6 Exp	87	5.0										
109	15-Aug	Below Fisher Coulee	175.6 Exp	79	3.5										
110	15-Aug	Below Fisher Coulee	175.6 Exp	81	4.1										
111	15-Aug	Below Fisher Coulee	175.6 Exp	28											
112	15-Aug	Turkey Joe	170.5 Exp	91	4.7	Ripe Male									
113	15-Aug	Turkey Joe	170.5 Exp	90	5.1	Ripe Male									
114	15-Aug	Turkey Joe	170.5 Exp	76	2.7										
115	15-Aug	Turkey Joe	170.5 Exp	63	2.0										
116	16-Aug	Power Plant Ruins	134.1	75	2.6										
117	16-Aug	Power Plant Ruins	134.1	90	5.2	Ripe Male									
118	16-Aug	Woodhawk	131.4	82	4.1										
119	31-Aug	Sevenmile Creek	173.5 Exp	71	2.9										
120	31-Aug	Sevenmile Creek	173.5 Exp	92	6.2										
121	31-Aug	Sevenmile Creek	173.5 Exp	85	4.5										
122	31-Aug	Sevenmile Creek	173.5 Exp	90	4.8										
123	31-Aug	Sevenmile Creek	173.5 Exp	90	6.3										
124	31-Aug	Sevenmile Creek	173.5 Exp	79	2.8										
125	31-Aug	Sevenmile Creek	173.5 Exp	79	2.8										
126	31-Aug	Sevenmile Creek	173.5 Exp	93	3.9										
127	31-Aug	Sevenmile Creek	173.5 Exp	74	2.6										
128	31-Aug	CK Creek	179.1 Exp	76	3.0										
129	31-Aug	CK Creek	179.1 Exp	77	2.5										

REFERENCES CITED

Allan, J.D. 1995. Stream ecology, structure and function of running waters. Chapman and Hall, New York.

Anderson, R.O., and S.J. Gutreuter. 1992. Length, weight and associated structural indices. Pages 283-300 *in* L.A. Nielsen and D.L. Johnson, editors. Fisheries techniques. American Fisheries Society, Bethesda, Maryland.

Bailey, R.G., and M.O. Allum. 1962. Fishes of South Dakota. Miscellaneous Publication No. 119. Museum of Zoology, University of Michigan, Ann Arbor.

Beamesderfer, R.C., and A.A. Nigro. 1993. Status and habitat requirements of the white sturgeon populations in the Columbia River downstream from McNary Dam. Final Report. Bonneville Power Administration. Project No. 86-50. vol 1-2.

Berg, R.K. 1981. Fish populations of the Wild & Scenic Missouri River, Montana. Montana Department of Fish, Wildlife & Parks. Federal aid to fish & wildlife restoration project. FW-3-R. Job 1-a.

Bureau of Land Management. 1994. River map of the Wild & Scenic Missouri. Fort Benton, Montana.

Busacker, G.P., I.R. Adelman, and E.M. Goolish. 1990. Growth. Pages 363-387 *in* C.B. Schreck and P.B. Moyle, editors. Methods for fish biology. American Fisheries Society, Bethesda, Maryland.

Carter, F.A., T. Buchanan, and S. Henry. 1983. Sicklefin chub, *Hybopsis meeki,* in the Mississippi River bordering Arkansas. Arkansas Academy of Science Proceedings 37: 80.

Conover, W.J.,1980. Practical nonparametrical statistics. 2nd ed. John Wiley and Sons pub. New York.

Cross, F.B. 1967. Handbook of the fishes of Kansas. Museum of Natural History Miscellaneous Publication No. 45. University of Kansas, Lawrence.

Davis, B., and R.J. Miller. 1967. Brain patterns in minnows of the genus *Hybopsis* in relation to feeding habits and habitats. Copeia 1967: 1-39.

Gardner, W.M., and R.K. Berg. 1980. An analysis of the instream flow requirements for selected fishes in the Wild & Scenic portion of the Missouri River. Draft Report. Montana Department of Fish, Wildlife & Parks, Ecological Services Division. Helena.

Gardner, W.M., and R.K. Berg. 1982. An analysis of the instream flow requirements for selected fishes in the Wild & Scenic portion of the Missouri River. Final Report. Montana Department of Fish, Wildlife & Parks, Ecological Services Division. Helena.

Gardner, W.M. and P.A. Stewart. 1987. Fishery of the lower Missouri River, Montana. Montana Department of Fish, Wildlife & Parks. Final report. Federal aid to fish & wildlife restoration project. FW-2-R. Helena.

Great Falls Tribune. Group wants fish declared endangered. July 3, 1994.

Gould, W.R. 1994_a. The recent distribution of sturgeon chub (*Macrhybopsis gelida*) in Montana. Biology Department, Montana State University, Bozeman.

Gould, W.R. 1994_b. Key to the fishes of Montana. Montana Cooperative Fisheries Research Unit. Biology Department, Montana State University, Bozeman.

Gelwicks, G.T. 1996. Status survey for sicklefin chub, sturgeon chub and flathead chub in the Missouri River, Missouri. Final Report. Missouri Department of Conservation, Fish and Wildlife Center. Columbia.

Harkin, J.R. 1956. Iowa fish and fishing. State Conservation Commision, DesMoines.

Hesse, L.W. 1993. The status of Nebraska fishes in the Missouri River (sicklefin chub, sturgeon chub, flathead chub, silver chub, speckled chub, plains minnow, and western silvery minnow). State of Nebraska, Game and Parks Commission, Norfolk.

Holton, G.D. 1990. A field guide to fishes of Montana. Montana Department of Fish, Wildlife & Parks, Helena.

Hunter, C. 1994. Fishes of special concern list, updated. Montana outdoors. September/October. Helena.

Iman, R.L. 1994. A data-based approach to statistics. Duxbury Press, Belmont, California.

Jerald, A. 1992. Age determination. Pages 301-324 *in* L.A. Nielsen and D.L. Johnson, editors. Fisheries Techniques. American Fisheries Society, Bethesda, Maryland.

Little, J.D., C.J. Killebrew and W.H. Tarplee. 1984. Nets. Pages 6.1-6.17 *in* C.F. Bryan, editor. Warm water streams techniques manual - fishes. Southern Division of American Fisheries Society, Louisiana Cooperative Fisheries Research Unit, Baton Rouge.

Neter, J., W. Wasserman, and M.H. Kutner. 1990. Applied linear statistical models. Irwin publishing, Boston, Ma.

Paloumpis, A.A. 1958. Measurement of some factors affecting the catch in a minnow seine. Proceedings of the Iowa Academy of Science 65: 580-86.

Pflieger, W.L. and T. B. Grace. 1987. Changes in the fish fauna of the lower Missouri River, 1940-1983. Pages 166-177 *in* W. Matthews and D. Heins editors. Community and evolutionary ecology of North American stream fishes. University of Oklahoma Press, Norman.

Pflieger, W.L. 1975. Fishes of Missouri. Missouri Department of Conservation, Columbia.

Reich, R.C., and D.S. Elsen. 1979. Status of the sturgeon chub (*Hybopsis gelida*) and sicklefin chub (*Hybopsis meeki*) in North Dakota. Prairie Naturalist 11:49-52.

Robinson, H.R. 1988. Freshwater fishes of Arkansas. Arkansas Game and Fish Commission. University of Arkansas press. Fayetteville.

SAS. 1991. Statistical Analysis System. Release 6.03 SAS Institute Inc. SAS Circle, Box 8000, Cary, NC 27513.

Stewart, D.D. 1981. The biology of sturgeon chub (*Hybopsis gelida* Girard) in Wyoming. M.S. Thesis, University of Wyoming, Laramie.

Tews, A. 1994. Pallid sturgeon and shovelnose sturgeon in the Missouri River from Fort Peck Dam to Lake Sakakawea, and in the Yellowstone River from Intake to its mouth. Final Report. Montana Department of Fish, Wildlife & Parks, Helena.

USGS. 1994. Provisional flow data for station 06115200, Missouri River near Landusky, Montana. Helena.

USGS. 1995_a. Provisional flow data for station 06115200, Missouri River near Landusky, Montana. Helena.

USGS. 1995_b. Water Resources Division. Observer field record - sediment, Missouri River near Landusky. Helena.

USFWS. 1994. 50 CFR 17 58996-59000. Endangered and threatened wildlife and plants; animal candidate review. Federal Register 59;219. Washington D.C.

Weisberg, S. 1989. A computer program for analyzing the growth of fish. School of statistics, University of Minnesota, St. Paul.

Werdon, S.J. 1993_a. Status report on sicklefin chub (*Macrhybopsis meeki*), a candidate endangered species. U.S. Fish & Wildlife Service, Ecological Services, Bismarck, North Dakota.

Werdon, S.J. 1993_b. Status report on sturgeon chub (*Macrhybopsis gelida*), a candidate endangered species. U.S. Fish & Wildlife Service, Ecological Services, Bismarck, North Dakota.