POPULATION STRUCTURE AND HABITAT USE OF BENTHIC FISHES ALONG THE MISSOURI AND LOWER YELLOWSTONE RIVERS

1997 Annual Report

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Executive Summary

The Benthic Fish Study is a multi-year, basin-wide research effort to help resource managers assess the status of benthic fishes, and to evaluate how channel and flow alteration affects Missouri River fishes. Benthic fishes (or bottom-dwelling fishes) were targeted because they include most species listed as "at risk" of extinction by resource agencies (e.g., pallid sturgeon, blue sucker, sicklefin chub), and important recreational and commercial fishes (e.g., catfishes, sauger, buffaloes). Data from the entire Missouri and Lower Yellowstone rivers will be useful for river managers because factors associated with healthy populations of fishes in one area of the river may provide the best model for conservation in other areas.

Overall research objectives are to: (1) describe and evaluate recruitment, growth, size structure, body condition, and relative abundance of selected benthic fishes, (2) measure physical habitat features (e.g., velocity, turbidity) in dominant habitats where fishes are collected, and (3) describe the use of dominant habitats by benthic fishes. Other objectives of the 1997 study were to: 1) suggest and implement any necessary improvements to existing methods learned from the 1996 season, 2) continue standardized field sampling for a second year, and 3) communicate project design and preliminary results to interested agencies and at professional meetings and conferences.

The benthic fish study team accomplished 100% of its fish collection plan again in 1997. This report only summarizes fish habitat and population data collected during the 1997 field season as well as age and growth data for fish collected during the 1996 field season. We have made only limited comparisons between the first two years of the study. The final field season, 1998, is required to thoroughly evaluate results of the 1996 and 1997 field seasons and synthesize temporal trends.

Methods Synopsis

Fieldwork was conducted in late summer and early fall (e.g., mid-July - October) depending on water temperature at each section. This period was selected because flows are generally low and all macrohabitats are present. The second year of field sampling began on July 13 and was completed in 13 weeks. The sampling schedule should reduce variability of fish and macrohabitat measurements, and insure that the majority of the young-of-year fishes were recruited to our gears. Fish collection gears include set gill nets, drifting trammel nets, boat electrofishing, seining, and trawling. All fish are identified and enumerated, but length and weight are measured only on the 26 taxa in the benthic guild. Physical habitat variables measured at all fish collection sites were depth, velocity, substrate type, air and water temperature, turbidity, conductivity, geographic location, river stage, and weather.

For analyses, the entire river was divided into three zones: least-impacted, inter-reservoir, and channelized. In each zone were segments (27 for the entire river) delineated by geomorphic and constructed features (e.g., major tributaries, dams). Six macrohabitats were sampled for fish in each segment. Macrohabitats were: main channel cross-over, outside bend, inside bend, tributary mouth, secondary channel: connected, and secondary channel: non-connected.

Results: Habitat

Physical habitat measurements at fish collection sites were compared among segments and macrohabitats. Depth increased gradually from upstream to downstream in the three main-channel macrohabitats (channel cross-over, outside bend, inside bend). Velocity was higher in channelized segments than other segments. Water temperature gradually increased from upstream to downstream with the exception of the Fort Peck and Lake Sakakawea tailwaters where flowing water kept temperatures below 16°C in four macrohabitats (channel cross-over, outside bend, inside bend, secondary channels: connected). Conductivity measurements were in two groups: 400-600 μS/cm from Montana to Lake Oahe, and 750-900 uS from Lake Francis Case to the confluence with the Mississippi River. Turbidity increased gradually from upstream to downstream with the exception of the inter-reservoir Segments in North Dakota and South Dakota where the readings were < 10 NTU's. Sand dominated all inter-reservoir and channelized segments, but gravel formed a much higher proportion of the total substrate in the least-impacted segments.

Results: Fish

We collected a total of 56,185 fishes representing at least 93 taxa, compared to 25,692 fishes of 78 taxa collected in 1996. All benthic species were collected, including a pallid sturgeon. Eight introduced species were found: bighead carp, chinook salmon, ciscoe, grass carp, mosquito fish, rainbow smelt, striped bass, and white bass. Hybrids were rarely found (22 fish) and were usually centrarchid sunfishes or suspected walleye-sauger hybrids. Species richness was highest (54 species) in downstream segments and lowest (27 species) in each of the Montana segments. In upper river sections, dominant taxa included flathead chub and *Hybognathus* species. In downstream sections, dominant species were gizzard shad, channel catfish, and flathead catfish.

Habitat use data from 1997 was similar to that found in 1996. Catch-per-unit-effort, habitat use, and size structure data are presented for 25 benthic fish species. As an example, 382 flathead catfish were captured in 1997, whereas 535 were captured in 1996. The fish were only found downstream from Gavins Point Dam. Most (40%) were captured in the Kansas section of the River. Flathead catfish were usually captured by electrofishing in outside bends, but fish were found in all macrohabitats except channel cross-overs, which are main river reaches where depth ($\bar{x} = 4.3$ m) and velocity ($\bar{x} = 1.23$ m/s) were higher than in other macrohabitats. Most flathead catfish were captured where depths were < 3 m, where velocities were < 0.6 m/s, where turbidity was 10-100 NTUs, and where temperatures were 24-30 °C. The length of the captured fish ranged from 50 to 1150 mm. The presence of many sizes indicates natural reproduction has been successful.

Age and growth analysis for fish collected in 1996 was done on 16 of the 26 benthic species using rays, spines, scales, or otoliths. We present preliminary results here reported as age-frequency histograms and mean back-calculated length figures that compare fish population metrics among least impacted, inter-reservoir, and channelized segments. For example, the mean length (standard error) of age-1 emerald shiners was 51(0.7) mm in the least-impacted zone, 53(1.3) mm in the inter-reservoir zone, and 51(3.2) mm in the channelized zone. There was no significant difference between zones in emerald shiner length at age-1.

Other Accomplishments

Participants in the project made 15 presentations to management agencies or as scientific papers at professional meetings. Several members have been instrumental in establishing the first (Columbia, MO), second (Nebraska City, NE), and in 1999, the third (Pierre, SD) annual

Missouri River Natural Resources Conference. Two Co-Principal Investigators served as liaison scientists to a group drafting the Missouri River Environmental Assessment Program. Project staff attended a June workshop at Yankton, SD to discuss the 1996 data, suggest improvements for the 1997 season, and report on individual Ph.D. projects. Six PhD projects that are being done at no extra cost to the funding agencies will add tremendously to the information about Missouri River fishes.

Participants

Research is being conducted by six Cooperative Research Units (Montana, Idaho, South Dakota, Iowa, Kansas, and Missouri) in the Biological Resources Division of the U. S. Geological Survey, and by the Montana Fish, Wildlife & Parks Department. Data management, data analysis, and quality assurance/quality control is done by the Environmental and Contaminants Research Center of the U. S. Geological Survey. Funding through 1997 was received from the U. S. Army Corps of Engineers, U. S. Bureau of Reclamation, U.S. Environmental Protection Agency, U. S. Fish and Wildlife Service, and U. S. Geological Survey- Biological Resources Division. The Cooperative Units are jointly supported by the six state universities (which waived partial overhead charges for this project), six state game and fish agencies, the Wildlife Management Institute, and U. S. Geological Survey-Biological Resources Division.

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Introduction

Modifications to the free-flowing Missouri River since the 1950's are well documented (Benson 1988). River management that includes conserving and restoring part of the natural river ecosystem necessitates knowledge of habitat requirements and population dynamics of fishes. The overall goal of this study is to provide natural resource agencies and their managers with fundamental biological and habitat use information for important bottom dwelling fishes collected in a standardized format for the entire Missouri and Lower Yellowstone rivers. The project is being performed by 1) a consortium of Cooperative Research Units in Montana, Idaho, South Dakota, Iowa, Kansas, and Missouri, 2) the Montana Department of Fish, Wildlife, and Parks, and 3) the Environmental and Contaminants Research Center. The Units and Center are in the Biological Resources Division of the U. S. Geological Survey. Hereafter the study participants will be collectively referred to as the Missouri River Benthic Fishes Consortium (MRBFC). Other acronyms for fish (including scientific names), participating agencies, fish collection gears and macro- and mesohabitats used in this report can be found in Appendix A.

The Missouri River "benthic fish study" is designed to evaluate population structure and habitat use of bottom-dwelling fishes along the main-stem Missouri and Lower Yellowstone rivers, exclusive of reservoirs. Project objectives are to 1) describe and evaluate recruitment, growth, size structure, body condition, and relative abundance of selected benthic fishes, 2) measure physical habitat features in dominant macrohabitats where fishes are collected, and 3) describe the use of dominant macrohabitats by benthic fishes. This group of fishes was selected because it contains eight species identified as "at risk" by state and federal agencies (pallid sturgeon, lake sturgeon, blue sucker, western silvery minnow, plains minnow, sturgeon chub, sicklefin chub, flathead chub) as well as important recreational and commercial species (e.g. catfishes, walleye, sauger, paddlefish, buffalo fishes).

The benthic fish study has a duration of 5 years. Two Annual Reports are complete and available (Braaten and Guy 1995, Dieterman et al. 1996). Objectives in **1995** were 1) establish the study design including hierarchical delineation of Missouri and Lower Yellowstone rivers study sections, segments, and macrohabitats, 2) establish a target list of benthic fishes, and 3) acquire equipment and evaluate fish sampling gears (Braaten and Guy 1995). Objectives in **1996** were to: 1) finalize study segments 2) develop and test Standard Operating Procedures (SOPs) for data collection and analysis, 3) continue preliminary sampling and gear testing, 4) conduct the first standardized field season, and 5) communicate project design and preliminary results to interested agencies (Dieterman et al. 1996). Objectives in **1997** were to: 1) suggest and implement any necessary improvements to existing methods learned from the 1996 season, 2) continue standardized field sampling for a second year, and 3) communicate project design and preliminary results to interested agencies and at professional meetings and conferences.

Methods

Sampling was conducted in late summer and early autumn. This time period was chosen because juveniles of most fishes would be present and recruited to collection gears, and water levels are typically low and relatively stable. Field sampling was completed within 13 weeks, which was within the planned interval for sampling (Table 1). All sampling was done according to Standard Operating Procedures (SOP) that were reviewed by the whole consortium, and approved by the Principal Investigator (D. Galat) and Quality Assurance Officer (L. Sappington).

The SOP manual also contains information on experimental design, coding for data sheets, and resumes for all project staff. We present only a synopsis of the methods below.

Table 1. Sampling schedule for Missouri River benthic fish and physical data collection in 1997. Bold numbers are transition weeks between months.

	Week of													
Segment	July			Aug.				Sept.					Oct.	
Agency	13-	20-	**7/27-8/2**	3-9	10-16	17-	24-	**8/31-9/6**	7-13	14-20	21-27	**9/28-10/4**	5-11	12-18
3, 5 MTCRU	X	X	X	X	X	X	X	X	X	X				
7, **8**, 9 MTFWP	X	X	X	X	X	X	X	X	X	X	X	X	X	
10, **12** IDCRU	X	X	X	X	X	X	X	X	X					
14, **15** SDCRU	X	X	X	X	X	X	X							
17, *19* IACRU		X	X	X	X	X	X	X	X					
22, *23* KSCRU				X	X	X	X	X	X	X	X	X		
25, *27* MOCRU		X	X	X	X	X	X	X	X	X	X	X	X	X

Habitat Designations and Study Design

A spatial hierarchical structure (Frissell et al. 1986) composed of nine sections, 27 segments, and six macrohabitats was developed based on geomorphic, hydrologic, and constructed features (e.g., major tributaries, dams) along the Missouri and Lower Yellowstone rivers (Table 2). Study sections and segments were grouped into least-impacted, inter-reservoir, and channelized zones, which are treated in this report in the following manner, <u>least-impacted sections and segments are underlined</u>, **inter-reservoir sections and segments are in bold**, and *channelized sections and segments are in italics.*

The six macrohabitats (see figure in Appendix B) common to all river segments are channel cross-overs (CHXO), inside bends (ISB), outside bends (OSB), tributary mouths (TRM), secondary channels connected (SCC) and secondary channels non-connected (SCN). Because some macrohabitats are very complex, they were further divided into smaller units termed mesohabitats. These include inside bend-sand bars (ISB-BARS), inside bend-channel borders (ISB-CHNB), inside bend-deep pools (ISB-POOL), inside bend-steep shorelines (ISB-STPS), large and small tributary mouths (TRM-LRGE and TRM-SMLL), deep secondary channels connected (SCC-DEEP), and shallow secondary channels connected (SCC-SHLW). Finally, a "wild card" macrohabitat (WILD) was identified for unusual macrohabitats (e.g., dam tailraces) that are unique to some segments. Five representatives of each macrohabitat and mesohabitat were sampled, when present, within a segment (Table 3).

A suite of physical habitat variables including bed form, depth (m), velocity (m/s), substrate, turbidity (NTU's), water temperature (°C), conductivity (uS/cm), macrohabitat latitude and longitude coordinates, time, weather conditions, and air temperature (°C) were measured at each fish collection site.

Table 2. List of designated sections and segments in the Missouri and Lower Yellowstone Rivers. Study sections and segments are grouped into three zones and highlighted in the following manner, least-impacted sections and segments are underlined, **inter-reservoir sections and segments are in bold**, and *channelized sections and segments are in italics*. Segments indicated by * were sampled in 1997. rmi = river miles.

Section (Agency) Description	Segment and Description (location by rmi) (total segment length)
1 (MTCRU) Missouri River headwater mainstem (170 rmi)	01 Loma Ferry - Rattlesnake Coulee (rmi 2052.8-2023.1) (29.7 rmi) 02 Rattlesnake Coulee-Arrow Creek (rmi 2023.1-1999.4) (23.7 rmi) 03* Arrow Creek-Birch Creek (rmi 1999.4-1980.6) (18.8 rmi) 04 Birch Creek-Sturgeon Island (rmi 1980.6-1952.2) (28.4 rmi) 05* Sturgeon Island-Beauchamp Coulee (rmi 1952.2-1882.7) (69.5 rmi)
	Fort Peck Reservoir (rmi 1882.7-1770.0)
2 (MTFWP) **Upper Inter-Reservoir I** (188rmi)	**06** Fort Peck Dam-Milk River (rmi 1770.0-1760.0) (10 rmi) **07*** Milk River-Hwy 13 bridge (Wolf Pt.) (rmi 1760.0-1701.0) (59 rmi) **08*** Wolf Pt.-Yellowstone River (rmi 1701.0-1582.0) (199 rmi)
3 (MTFWP) (71 rmi) Lower Yellowstone River	09* Intake Diversion Dam-Missouri River Confluence (rmi 71.0-0.0)
4 (IDCRU) **Upper Inter- Reservoir II** (47 rmi)	**10*** Yellowstone River-Lake Sakakawea Headwaters (rmi 1582.0-1552.0) (30 rmi) **11** Lake Sakakawea Headwaters-Lake Sakakawea (rmi 1552.0-1535.0) (17 rmi)
	Lake Sakakawea (rmi 1535-1389)
5 (IDCRU) **Upper Inter-Reservoir III** (114 rmi)	**12*** Garrison Dam-Lake Oahe Headwaters (rmi 1389.0-1304.0) (85 rmi) **13** Lake Oahe Headwaters-Lake Oahe (rmi 1304.0-1275.0) (29 rmi)
	Lakes Oahe, Sharpe, and Francis Case (rmi 1275.0-880.0)
6 (SDCRU) **Inter-Reservoir IV and Unchannelized Area** (115 rmi)	**14*** Fort Randall Dam-Lewis and Clark Lake Headwaters (rm 880.0-835.0) (45 rmi)
	Lewis and Clark Lake (rmi 835.0-810.0)
	15* Gavins Point Dam-Ponca, Nebraska (rmi 810.0-753.0) (57 rmi) **16** Ponca, Nebraska-Big Sioux River (rmi 753.0-740.0) (13 rmi)
7 (IACRU) *Channelized I* (242 rmi)	*17** Big Sioux River-Little Sioux River (rmi 740-669.2) (70.8 rmi) *18* Little Sioux River-Platte River (rmi 669.2-595.5) (73.7 rmi) *19** Platte River-Nishnabotna River (rmi 595.5-542.0) (53.5 rmi) *20* Nishnabotna River-Tarkio River (rmi 542.0-498.0) (44 rmi)
8 (KSCRU) *Channelized II* (278 rmi)	*21* Rulo, Ne-St. Joseph, MO (rm 498.0-440.0) (58 rmi) *22** St. Joseph, MO-Kansas City, MO (rm 440.0-367.5) (72.5 rmi) *23** Kansas City, MO-Grand River, MO (rm 367.5-250.0) (117.5 rmi) *24* Grand River, MO-Glasgow, MO (rm 250.0-220.0) (30 rmi)

Table 1. Continued.

Section (agency) Description	Segment and Description (location by rmi) (total segment length)
9 (MOCRU) *Channelized III* (220 rmi)	*25** Glasgow River, MO-Osage River (rm 220.0-130.4) (89.6 rmi) *26* Osage River-about 20 mi upstream of St. Charles, MO (rm 130.4-50.0) (80.4 rmi) *27** River mile 50.0-Mississippi River Confluence (rm 0.0)

Table 3. The number of replicate macro- and meso-habitats sampled in MRBFC study segments in 1997 (CHXO=Channel Cross-over, ISB-BARS=Inside Bend-sand bar, ISB-CHNB=Inside Bend-channel border, ISB-POOL=Inside Bend-pool, ISB-STPS=Inside Bend-steep shoreline, OSB=Outside Bend, SCC-DEEP=Secondary Channel Connected-Deep, SCC-SHLW=Secondary Channel Connected-shallow, SCN=Secondary Channel Non-connected, TRM-SMLL=Tributary Mouth-small, TRM-LRGE=Tributary Mouth-large). Least-impacted segment numbers = underlined, inter-reservoir segment numbers = bold font, and channelized segment numbers = italic font.

	Macro- and Meso-habitats										
Segment	CHXO	ISB-BARS	ISB-CHNB	ISB-POOL	ISB-STPS	OSB	SCC-DEEP	SCC-SHLW	SCN	TRM-SMLL	TRM-LRGE
3	5	5	5		1	5	1	5	1		
5	5	5	5		2	5	5	5	3		
7	5	5	5			5	5	2	5	5	
8	5	5	5			5	5	5	5	5	1
9	5	5	5			5	5	5	6		
10	5	2	3			4	1	5	4		1
12	5	2	3			4		5	5	2	
14	5		5		3	5	5	1	1	5	
15	5	5	5	5		5	5	5	2	5	
17	5	5	5	5	5	5				5	1
19	5			5	5	5	2			5	1
22	5		5	5	5	5			3	5	2
23	5	1	5	5	5	5	5			5	1
25	5	5	5	5	5	5	5	5		5	2
27	5	5	5	5	5	5	5	5	5	4	

Two study designs were drafted in 1995, a full study that included all 27 segments and a reduced study that included fewer segments for study (Braaten and Guy 1995). Due to financial and logistic constraints, a design that included 18 segments was chosen in 1996, whereas in 1997, 15 segments were sampled.

Fish Collection

Twenty-six benthic fishes historically present in five of the six states under study, were targeted for sampling (Table 4). Age and growth analyses were conducted on 15 of the 26 species. Five gears were used for fish collection: experimental gill nets (30.5 m long x 1.8 m high, with four 7.6 m panels of 19, 38, 51, and 76 mm square mesh), trammel nets (22.9 m long, with an inner wall 2.4 m deep with 25 mm bar mesh and a 1.8 m deep outer wall of 203 mm bar mesh), bag seines (10.7 m long x 1.8 m high with 5 mm mesh and a 1.8 x 1.8 x 1.8 m bag), a benthic trawl (2 m wide x 0.5 m high x 5.5 m long with 3.2 mm inner mesh), and boat electrofishing (5,000 watt generator using pulsed DC current and 2 netters with 5 mm mesh dip nets) (Table 5). A minimum of two fish collection gears were used in each mesohabitat. The exception was SCC-SHLW and ISB-BARS where only a seine was used.

We increased sampling effort in 1997, thinking that more effort concentrated in fewer segments would allow better estimated of fish population and community structure, and would provide more fish for age and growth analysis. Consequently, we worked on 15 segments in 1997 instead of 18. The number of gear subsamples in macro- and mesohabitats was increased from two to three for all gears except electrofishing and stationary gill net; for these gears, we increased effort, which is the amount the gear was used in a macro- or mesohabitat. Most electrofishing subsamples were increased from 5 minutes to 10 minutes and gill net sets were

Table 4. List of fishes in the Missouri River benthic fish guild showing geographic ranges (from Hesse et al. 1989), and functional category. An * indicates species used for age and growth analysis.

Species	Geographic Range[a]	Functional Category[b]
Pallid sturgeon	MO, KS, IA, SD,	
Scaphirhynchus albus	ND, MT	TE
Shovelnose Sturgeon*	MO, KS, IA, SD,	
Scaphirhynchus platorynchus	ND, MT	
Common carp	MO, KS, IA, SD,	
Cyprinus carpio	ND, MT	C
Flathead chub*	MO, KS, IA, SD,	
Platygobio gracilis	ND, MT	TE & P
Sturgeon chub	MO, KS, IA, SD,	
Macrhybopsis gelida	ND, MT	TE & P
Sicklefin chub*	MO, KS, IA, SD,	
Macrhybopsis meeki	ND, MT	TE & P
Emerald shiner*	MO, KS, IA, SD,	
Notropis atherinoides	ND, MT	P
Sand shiner	MO, KS, IA, SD,	
Notropis stranimeus	ND, MT	P
Western silvery minnow*	MO, KS, IA, SD,	
Hybognathus argyritis	ND, MT	TE & P
Plains minnow*	MO, KS, IA, SD,	
Hybognathus placitus	ND, MT	TE & P
Brassy minnow*	MO, KS, IA, SD,	
Hybognathus hankinsoni	ND, MT	P
Fathead minnow	MO, KS, IA, SD,	
Pimephales promelas	ND, MT	P
Blue sucker*	MO, KS, IA, SD,	
Cycloptus elongatus	ND, MT	TE
Bigmouth buffalo	MO, KS, IA, SD,	
Ictiobus cyprinellus	ND, MT	C

Table 4. Continued.

Species	Geographic Range[a]	Functional Category[b]
Smallmouth buffalo*	MO, KS, IA, SD,	
Ictiobus bubalus	ND, MT	C
River carpsucker*	MO, KS, IA, SD,	
Carpiodes carpio	ND, MT	C
White sucker	MO, KS, IA, SD,	
Catostomus commersoni	ND, MT	P
Shorthead redhorse	MO, KS, IA, SD,	
Moxostoma macrolepidotum	ND, MT	
Flathead catfish*	MO, KS, IA, SD	
Pylodictus olivarus		R
Channel catfish*	MO, KS, IA, SD,	
Ictalurus punctatus	ND, MT	R
Blue catfish	MO, KS, IA, SD	
Ictalurus furcatus		R
Stonecat	MO, KS, IA, SD,	
Noturus flavus	ND, MT	P
Burbot	MO, KS, IA, SD,	
Lota lota	ND, MT	TE
Walleye	MO, KS, IA, SD,	
Stizostedion vitreum	ND, MT	R
Sauger*	MO, KS, IA, SD,	
Stizostedion canadense	ND, MT	R
Freshwater drum*	MO, KS, IA, SD,	
Aplodinotus grunniens	ND, MT	C & R

[a] MO (Missouri), KS (Kansas), IA (Iowa), SD (South Dakota), ND (North Dakota, MT (Montana)
[b] TE (species at risk), P (prey species), C (commercial species), R (recreational species)

Table 5. Fish collection gears used in each Missouri River macro- and meso-habitat during 1997.

	Collection gears				
Macro- and meso-habitats	Bag seine	Experimental gill net	Boat electrofishing	Benthic trawl	Drifting trammel net
Channel cross-overs				X	X
Outside bends			X	X	X
Inside bends					
channel border				X	X
bars	X				
pools		X			
steep shorelines			X		
Tributary mouths					
small		X	X		
deep			X	X	X
Secondary channels: non-connected	X	X	X		
Secondary channels: connected					
shallow	X				
deep	X		X	X	X

changed from 3-hour daytime sets to 12-18-hour overnight sets. In addition, electrofishing was added as a fish collection technique in SCN and SCC-DEEP habitats.

Accomplishments

Standard Operating Procedures

Standard Operating Procedures were modified for the 1997 field season (Sappington et al. 1997). The SOPs covered the experimental design, aquatic macrohabitat classification, standardized use of fish collecting gears, fish identification, measurement, and sampling, including collection of age and growth structures, standardized measurement of physical habitat variables, data collection and quality assurance and quality control procedures, and data analysis (Table 6).

Presentations and Workshops

From January 1, 1997 to January 1, 1998, the Missouri River Benthic Fish Consortium members made 15 presentations about the benthic fish study and participated in several workshops and meetings (Table 7). Two workshops were held prior to the 1998 field season. The first was held in Yankton, South Dakota at the Corps of Engineers Office in June 1997. Doug Dieterman and Mike Ruggles presented data from the 1996 field season to MRBFC members and attendees from state and federal agencies. Additionally, changes to SOPs were discussed, Ph.D. candidates presented dissertation proposals, and Mark Wildhaber presented an overview of statistical analysis and hypothesis testing. The group went over SOPs and macrohabitat delineation and classification on a field trip.

Table 6. Standard operating procedures developed for data collection and analyses in 1997 and personnel responsible for them. Summarized from Sappington et al. (1997).

Standard operating procedure	Responsible agency (Personnel)
	Sample Design
Aquatic Macrohabitat Classification	MOCRU (Doug Dieterman, David Galat)
Sampling Strategy	SDCRU (Brad Young, Chuck Berry)
	Fish Collection
Bag seining	IACRU (Mark Pegg, Clay Pierce)
Benthic trawl	MTCRU (Lee Bergstedt, Bob White)
Electrofishing	KSCRU (Pat Braaten, Chris Guy)
Gill net	SDCRU (Brad Young, Chuck Berry)
Trammel net	MTFWP (Mike Ruggles)
	Fish Identification and Measurement
Population structure, age, and growth	IACRU (Mark Pegg, Clay Pierce)
Fish Treatment	SDCRU (Brad Young, Chuck Berry)
Pallid sturgeon handling	ECRC (Linda Sappington)
	Physical habitat Measurements
Bed form	MOCRU (Doug Dietermann, David Galat)
Depth and velocity	MOCRU (Doug Dietermann, David Galat)
Global positioning system	SDCRU (Brad Young, Chuck Berry)
Substrate	SDCRU (Brad Young, Chuck Berry)
Time	IDCRU (Tim Welker, Dennis Scarnecchia)
Turbidity	KSCRU (Pat Braaten, Chris Guy)
Water temperature & conductivity	KSCRU (Pat Braaten, Chris Guy)
Weather and air temperature	MTCRU (Lee Bergstedt, Bob White)
	Data Analyses
Experimental design	ECRC (Mark Wildhaber)
Fish attribute and physical habitat factors	ECRC (Mark Wildhaber)
Hypotheses	ECRC (Mark Wildhaber)
Statistical analyses	ECRC (Mark Wildhaber)
	Data Collection and QA/QC Standard Operating Procedures
Data sheet coding instructions	ECRC (Linda Sappington)
Chain of custody	ECRC (Linda Sappington)

Table 7. Oral and poster presentations given by Missouri River Benthic Fish Consortium members in 1997, exclusive of bi-annual consortium workshops. MTCRU-Montana Coop Unit, MTFWP-Montana Fish, Wildlife, and Parks, IDCRU-Idaho Coop Unit, SDCRU-South Dakota Coop Unit, IACRU-Iowa Coop Unit, KSCRU-Kansas Coop Unit, MOCRU-Missouri Coop Unit.

Presentation Title	**Agency/Meeting**	**Presenter**	**Format**	**Location and Date**
Ecology and Structure of Fish Communities in the Missouri and Lower Yellowstone Rivers	University of Idaho Faculty and Students	IDCRU	Oral	Moscow, ID October 1997
1996 Benthic Fish of the Missouri and Lower Yellowstone Rivers	Great Plains Fisheries Workers Association	MTFWP	Oral	Bozeman, MT February 1997
1997 Benthic Fish of the Yellowstone and Lower Missouri Rivers in Montana	USGS & BOR Decision Support System Meeting	MTFWP	Oral	Fort Collins, CO December 1997
1997 Benthic Fish Review for the Missouri and Yellowstone Rivers in Montana	Upper Basin Pallid Sturgeon Working Group	MTFWP	Oral	Miles City, MT December 1997
Distribution of Benthic Fishes in the Missouri River	Annual Meeting of the Dakota Chapter of the AFS	SDCRU	Oral	Fargo, ND February 1997
Population Structure and Habitat Use of Benthic Fishes in the Missouri River	Annual Meeting of the Dakota Chapter of the AFS	SDCRU	Poster	Fargo, ND February 1997
Overview of the Benthic Fish Study - Objectives and Preliminary Results	South Dakota Missouri River and Reservoir Management Conference	SDCRU	Oral	Brookings, SD March 1997
The Benthic Fish Study: An Example of Cooperative Information Management	Information Management Workshop	SDCRU	Oral	Sioux Falls, SD May 1997
The Status of the Benthic Fish Study on the Missouri River	Annual Meeting of the Missouri River Coalition	SDCRU	Oral	Sioux City, IA October 1997
Longitudinal Age and Growth Comparison of Missouri River Shovelnose Sturgeon	59th Midwest Fish and Wildlife Conference	IACRU	Oral	Milwaukee, WI December 1997

Presentation Title	Agency/Meeting	Presenter	Format	Location and Date
Population Structure and Habitat Use of Benthic Fishes Along the Missouri and Lower Yellowstone Rivers	59th Midwest Fish and Wildlife Conference	KSCRU	Poster	Milwaukee, WI December 1997
Population Structure and Habitat Use of Benthic Fishes Along the Missouri River	1st Annual Conference on Natural Resources of the Missouri River Basin	MOCRU	Poster	Columbia, MO January 1997
Population Structure and Habitat Use of Benthic Fishes Along the Missouri River	Missouri Forest, Fish, and Wildlife Conference	MOCRU	Poster	Osage Beach, MO February 1997
Population Structure and Habitat Use of Benthic Fishes Along the Missouri River	USGS-BRD	MOCRU	Oral	Reston, VI July 1997
Population Structure and Habitat Use of Benthic Fishes Along the Missouri River	Lower Mississippi River Conservation Commission Annual Meeting	MOCRU	Oral	Cape Girardeau, MO July 1997

The second workshop was held in March 1998 in conjunction with the Second Annual Conference on Natural Resources of the Missouri River Basin at the Lied Conference Center in Nebraska City, Nebraska. Several presentations were given at the conference by MRBFC members that discussed the study. The workshop was held at the conclusion of the conference. Topics discussed included final forms of SOPs, the degree of access contributing agencies had to data, synthesis of data basin wide, and the 1997 annual report. Ph. D. candidates gave presentations on dissertations proposals and preliminary data analysis.

Fieldwork: Physical Habitat Variables

The physical conditions of the river in 1997 were not typical but sampling was completed as scheduled. A harsh winter throughout the basin and deep snow packs in the mountains yielded unusually high flows. The upper and inter-reservoir zones were most affected (Figure 1), however the channelized zone where flows are governed by large tributaries (e.g. Platte River) did not experience as much flow increase. The high flows caused the river to widen and thus habitat conditions changed. For example, high water reduced the number of ISB-BAR, but increased the number of flooded backwaters (Table 3). The number of replicate mesohabitats sampled varied due to availability in each section (Table 3).

Physical habitat measurements were compared among segments and macrohabitats by first averaging subsamples (i.e., sites within replicate macrohabitats where an individual gear is deployed and physical habitat measurements taken) by gear within each mesohabitat. These gear values were then averaged to produce a value for each mesohabitat. For example, ISB-BARS and ISB-CHNB mesohabitats were averaged for an ISB macrohabitat. Thus, data were collapsed across macrohabitats and segments. The 5 macrohabitat replicate means were then averaged within each segment.

Average depths across segments and macrohabitats ranged from 0.1-6.84 m, average velocities from 0.0-3.91 m/s, average water temperatures from 12.8-30.1 °C, and average turbidities from 3-832 NTUs (Table 8). Means of physical habitat variables were compared among segments and macrohabitats using two-way analysis of variance (ANOVA). In order to stabilize variance, turbidity and conductivity were transformed using $\log_{10}$ and proportions of gravel, sand, and silt were transformed using arcsine of the square root. We did not address homogeneity of variance due to the robustness of ANOVA when replicates are equal or near equal as is the case across segments in this study (Miliken and Johnson 1984). If segment by macrohabitat interactions were detected, plots of each physical habitat variable by segment were examined for each macrohabitat to discern where interactions occurred. These interaction plots are presented below to help provide segment trends and linkages to fish data in subsequent report sections. Fisher's Least Significant Difference test for preplanned comparisons was used to evaluated mean differences. An alpha of 0.05 was selected as evidence of significance in all comparisons. Summary statistics for depth, velocity, water temperature, turbidity, and conductivity for the entire Missouri River and Lower Yellowstone River can be found in Table 8.

Although physical habitat variables were measured at each fish collection location to characterize the habitats where fish were sampled, they also provide an index to trends in physical habitat conditions among segments and macrohabitats. Our stratified random sampling approach to measuring physical habitat variables does not yield an accurate representation of habitat availability in each segment because habitats were not sampled in proportion to their availability.

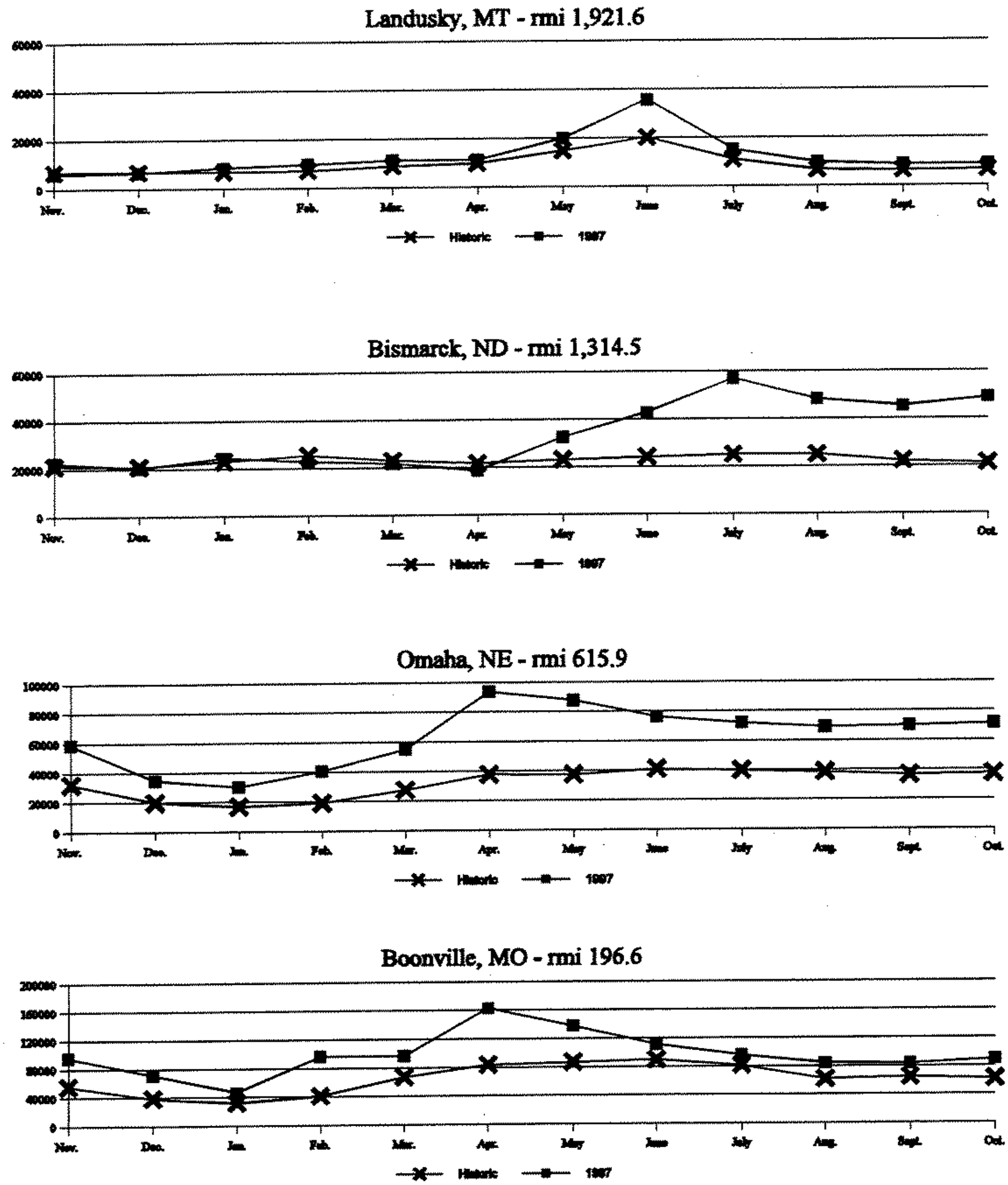


Figure 1. Historic (X's: Landusky- 1934-1996; Bismarck- 1954-1996; Omaha- 1953-1996; Booneville- 1953-1996) and 1997 (squares) mean monthly discharge for four locations along the Missouri River. Note y-axis scales vary with gauging station location.

In the following discussion of each habitat variable we have included a figure showing the habitat value plotted by macrohabitat across all segments, and a matrix table that shows statistical similarities between segments for that variable. Some figures have gaps in the habitat value lines because that macrohabitat was absent from that segment. Specifically, tributary mouths were not sampled in segments 3 or 5, secondary channels: non-connected were not sampled in segments *17, 19, 23*, and *25*, and secondary channels-connected were not sampled in segment *17*.

Table 8. Summary statistics for depth, velocity, water temperature, turbidity and conductivity in six macrohabitats across all Missouri and Yellowstone River study segments in 1997. Turbidity and conductivity means and SD's are $\log_{10}$ transformed. Minimum and maximum values are segment averages.

Macrohabitat	Characteristic	N	Mean	SD	Minimum-Maximum
CHXO	Depth (m)	75	4.30	1.83	1.07 - 8.15
	Velocity (m/s)	73	1.23	0.55	0.28 - 3.91
	Water temperature (C)	75	22.02	4.38	12.87 - 28.17
	Turbidity (NTUs)	75	1.55	0.53	0.50 - 2.88
	Conductivity (μS/cm)	73	2.80	0.13	2.52 - 2.97
OSB	Depth (m)	73	4.43	1.51	0.82 - 6.84
	Velocity (m/s)	73	1.04	0.35	0.28 - 2.01
	Water temperature (C)	73	22.10	4.46	12.77 - 28.18
	Turbidity (NTUs)	73	1.51	0.50	0.57 - 2.85
	Conductivity (μS/cm)	72	2.81	0.12	2.52 - 2.98
ISB	Depth (m)	75	2.48	1.29	0.34 - 5.94
	Velocity (m/s)	75	0.57	0.23	0.15 - 1.60
	Water temperature (C)	75	22.19	4.32	12.75 - 28.35
	Turbidity (NTUs)	75	1.59	0.51	0.49 - 2.91
	Conductivity (μS/cm)	74	2.81	0.12	2.55 - 3.05
TRM	Depth (m)	60	2.03	1.12	0.49 - 0.03
	Velocity (m/s)	57	0.04	0.09	0.0 - 0.61
	Water temperature (C)	59	22.11	3.47	13.6 - 27.7
	Turbidity (NTUs)	60	1.54	0.39	0.85 - 2.81
	Conductivity (μS/cm)	57	2.83	0.12	2.46 - 3.11
SCC	Depth (m)	98	1.27	0.95	0.10 - 3.62
	Velocity (m/s)	98	0.41	0.24	0.0 - 1.05
	Water temperature (C)	98	21.23	4.47	12.76 - 30.08
	Turbidity (NTUs)	95	1.57	0.42	0.60 - 2.92
	Conductivity (μS/cm)	98	2.79	0.11	2.58 - 2.98
SCN	Depth (m)	40	1.08	0.53	0.31 - 3.00
	Velocity (m/s)	40	0.03	0.06	0.0 - 0.32
	Water temperature (C)	40	20.74	3.87	14.8 - 28.9
	Turbidity (NTUs)	40	1.54	0.44	0.70 - 2.92
	Conductivity (μS/cm)	40	2.79	0.10	2.56 - 3.07

Depth

Depth (m) differed significantly among segments (P = 0.001), and macrohabitats (P = 0.001), but there was a significant interaction (P = 0.0001). Depth increased in continuous macrohabitats (CHXO, ISB, and OSB) from upper to lower segments while discrete macrohabitats (TRM, SCC, and SCN) showed no longitudinal trends (Figure 2). Macrohabitats were significantly different (P < 0.05) from each other except for OSB and CHXO, and SCC and SCN. Depth decreased in macrohabitats in the following order; OSB, CHXO, ISB, TRM, SCC, and SCN (Table 8). Channelized, inter-reservoir, and least-impacted segments generally grouped together in segment only comparisons (Figure 3). Depth (m) was greatest in segment *19* (sample mean = 4.06) followed in order by *17* (4.02 m), *22* (3.80 m), *23* (3.75 m), **14** (3.14 m), *25* (2.84 m), **15** (2.70 m), *27* (2.64 m), **10** (2.63 m), **8** (2.28 m), **7** (2.23 m), **12** (2.16 m), 9 (1.75 m), 5 (1.52 m), and 3 (1.10 m). In general, segment depths were shallowest in least-impacted segments and deepest in channelized segments.

Depth

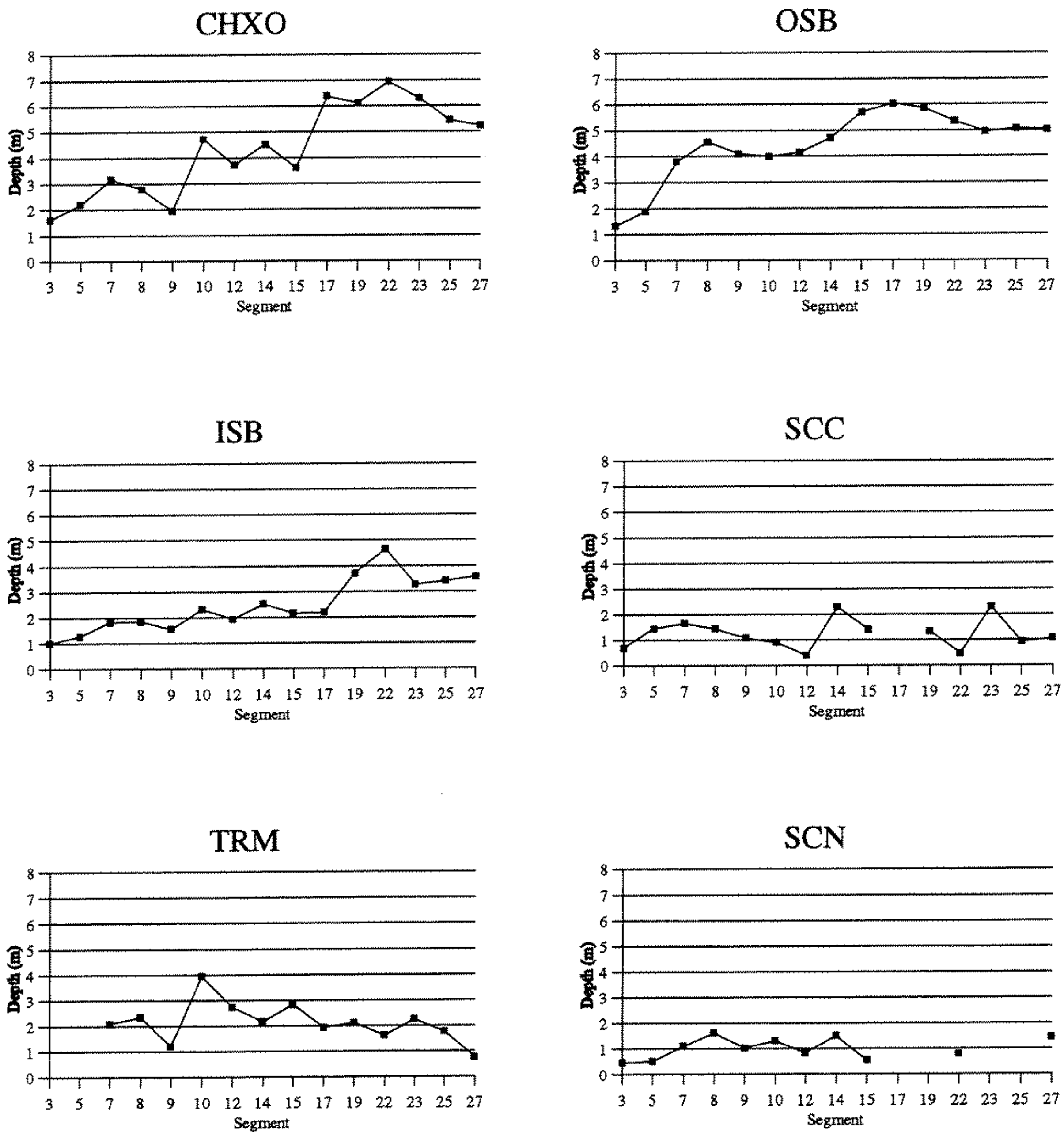


Figure 2. Average depth (m) in Missouri and Yellowstone (segment 9) River study segments measured in 1997 in six macrohabitats. CHXO-channel crossover, OSB-outside bend, ISB-inside bend, SCC-secondary channel connected, TRM-tributary mouth, SCN-secondary channel non-connected. Least-impacted segments: 3, 5, and 9; Inter-reservoir segments: 7, 8, 10, 12, 14, and 15; Channelized segments: 17, 19, 22, 23, 25, and 27.

	3	5	**7**	**8**	9	**10**	**12**	**14**	**15**	*17*	*19*	*22*	*23*	*25*	*27*
3	N	N													
5		N			N										
7			**I**	**I**		X	X								X
8				**I**		**I**	**I**		**I**						X
9					N		X								
10						**I**	**I**		**I**					X	X
12							**I**								
14								**I**	**I**					X	
15									**I**					X	X
17										*C*	*C*	*C*	*C*		
19											*C*	*C*	*C*		
22												*C*	*C*		
23													*C*		
25														*C*	*C*
27															*C*

Figure 3. Depth comparisons matrix for 15 Missouri River study segments where depth was measured in 1997. A box with a letter in it means that those segments are not statistically different from each other. N = natural or least-impacted segments, **I** = inter-reservoir segments, and *C* = channelized segments. *C*, **I**, and N indicate where two channelized, inter-reservoir, or least-impacted segments are not different from each other. An X indicates 2 segments not otherwise grouped are statistically the same.

Velocity

Velocity (m/s) differed significantly among segments (P = 0.0001), macrohabitats (P = 0.001), and had a significant interaction (P = 0.001). Velocity increased in channelized segments in CHXOs and OSBs, especially in the transition area between inter-reservoir and channelized segments, but showed no trends across segments in ISBs, SCC, SCN, and TRMs (Figure 4). Average velocities were slowest in SCN and TRMs, while CHXOs and OSBs exhibited the greatest average velocities (Table 8). ISBs and SCC all had intermediate average velocities. In general, most least-impacted and inter-reservoir segments were not significantly ($P < 0.05$) different from each other. However, channelized segments *17* and *19* were significantly different from most all other segments (Figure 5). Mean velocities decreased across segments in the following order; segment *19* (0.99 m/s), *17* (0.90 m/s), *23* (0.85 m/s), 3 (0.81 m/s), *22* (0.68 m/s), *25* (0.57 m/s), *27* (0.56 m/s), **10** (0.55 m/s), **12** (0.54 m/s), **15** (0.52 m/s), 5 (0.48 m/s), **7** (0.48 m/s), **8** (0.47 m/s), and 9 (0.43 m/s). In general, the highest average current velocities were found in channelized segments.

Velocity

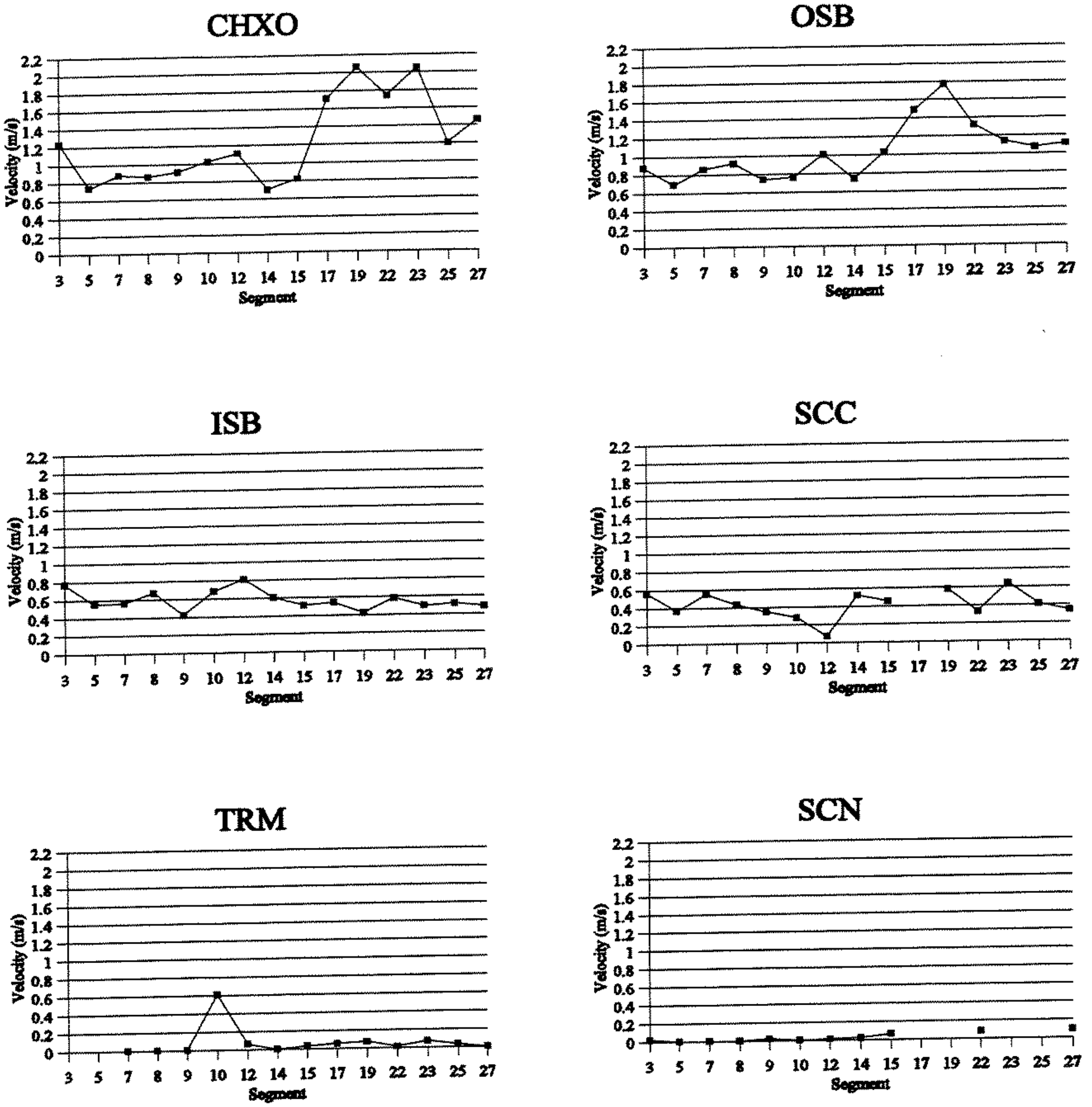


Figure 4. Average water velocity (m/s) in Missouri and Yellowstone (segment 9) River study segments measured in 1997 in six macrohabitats. CHXO-channel crossover, OSB-outside bend, ISB-inside bend, SCC-secondary channel connected, TRM-tributary mouth, SCN-secondary channel non-connected. Least-impacted segments: 3, 5, and 9; Inter-reservoir segments: 7, 8, 10, 12, 14, and 15; Channelized segments: 17, 19, 22, 23, 25, and 27.

	3	5	**7**	**8**	9	**10**	**12**	**14**	**15**	*17*	*19*	*22*	*23*	*25*	*27*
3	N									X		X	X		
5		N	N	N	N	X	X	X	X			X	X	X	
7			**I**	**I**	N	X	X	X	X					X	X
8				**I**	X	**I**	**I**	**I**	**I**					X	X
9					N	X	X	X	X						
10						**I**	**I**	**I**	**I**					X	X
12							**I**	**I**	**I**					X	X
14								**I**	**I**					X	X
15									**I**					X	X
17										*C*	*C*		*C*		
19											*C*				
22												*C*		*C*	
23													*C*		
25														*C*	*C*
27															*C*

Figure 5. Velocity comparisons matrix for 15 Missouri River study segments where velocity was measured in 1997. A box with a letter in it means that those segments are not statistically different from each other. N = natural or least-impacted segments, **I** = inter-reservoir segments, and *C* = channelized segments. *C*, **I**, and N indicate where two channelized, inter-reservoir, or least-impacted segments are not different from each other. An X indicates 2 segments not otherwise grouped are statistically the same.

Water Temperature

Water temperature(°C) differed significantly among segments ($P = 0.001$), but not macrohabitats ($P = 0.8823$). However, there was a significant ($P = 0.0003$) interaction between segments and macrohabitats. Water temperatures in all macrohabitats displayed similar trends of increasing temperature from upper to lower Missouri River (Figure 6). However, lowest average water temperatures for most macrohabitats were found in segments below Fort Peck Dam (segment 7) and Garrison Dam (segment 12). Fort Peck Reservoir and Garrison Reservoir (Lake Sakakawea) are the two largest impoundments in this study and exhibit hypolimnetic releases. Generally, most least-impacted and inter-reservoir segments were significantly ($P < 0.05$) different from each other, whereas differences among channelized segments tended to have similar temperatures (Figure 7). Temperatures decreased across segments in the following order; *27* (25.79 °C), *19* (25.09 °C), *17* (24.68 °C), *25* (24.56 °C), *22* (24.52 °C), *23* (24.43 °C), **15** (24.05 °C), **14** (23.76 °C), 3 (21.64 °C), 5 (20.90 °C), 9 (20.47 °C), **10** (20.11 °C), **8** (17.48 °C), **12** (16.51 °C), and **7** (14.40 °C). Average segment temperatures were generally warmest in the lower, channelized segments and coldest in segments below Fort Peck (segment **7**) and Garrison (Segment **12**) Dams.

Temperature

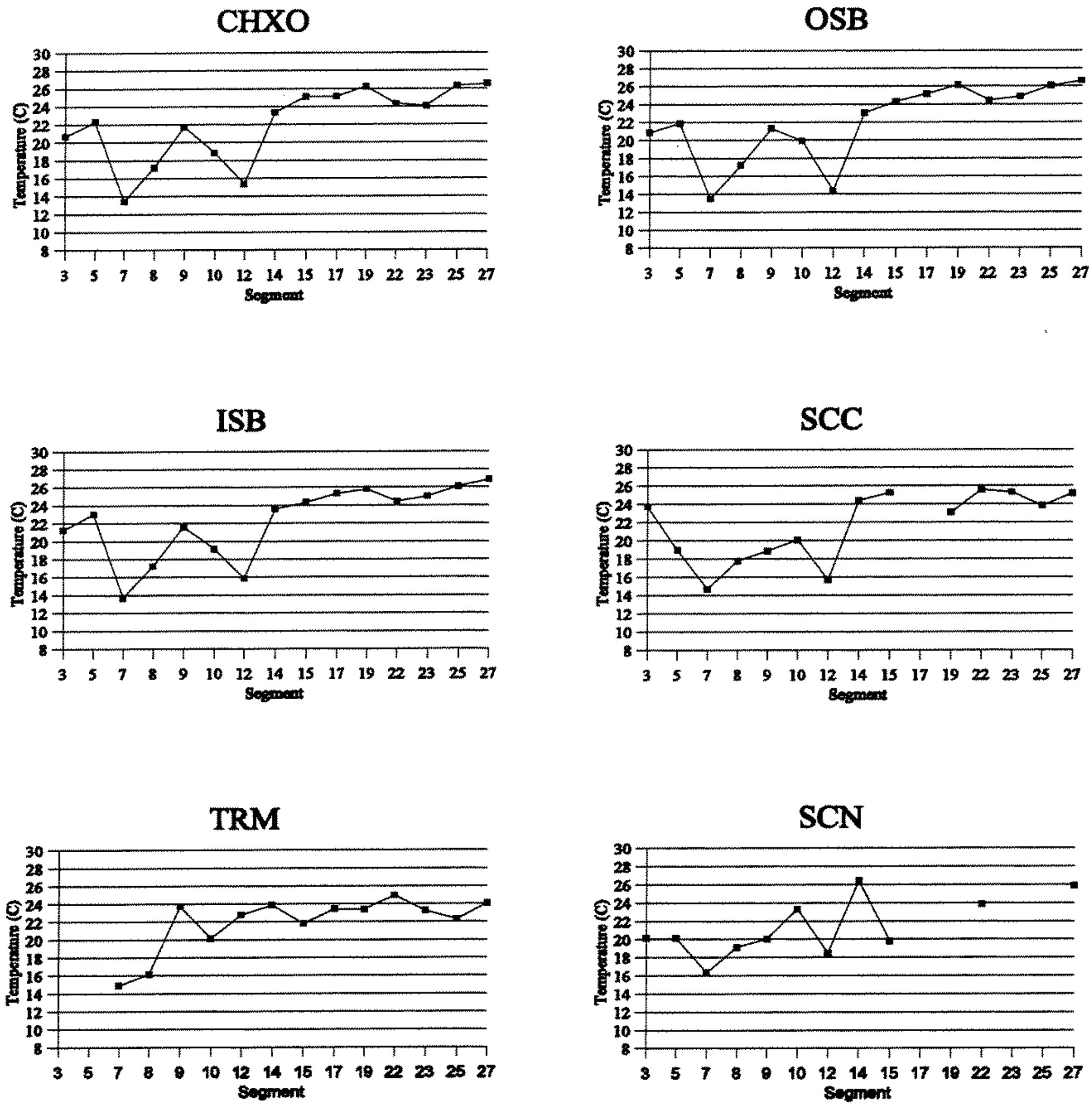


Figure 6. Average water temperatures (°C) in Missouri and Yellowstone (segment 9) River study segments measured in 1997 in six macrohabitats. CHXO-channel crossover, OSB-outside bend, ISB-inside bend, SCC-secondary channel connected, TRM-tributary mouth, SCN-secondary channel non-connected. Least-impacted segments: 3, 5, and 9; Inter-reservoir segments: 7, 8, 10, 12, 14, and 15; Channelized segments: 17, 19, 22, 23, 25, and 27.

	3	5	**7**	**8**	9	**10**	**12**	**14**	**15**	*17*	*19*	*22*	*23*	*25*	*27*
3	N	N			N										
5		N			N	X									
7			**I**												
8				**I**			**I**								
9					N	X									
10						**I**									
12							**I**								
14								**I**	**I**	X		X	X	X	
15									**I**	X	X	X	X	X	
17										*C*	*C*	*C*	*C*	*C*	*C*
19											*C*	*C*	*C*	*C*	*C*
22												*C*	*C*	*C*	
23													*C*	C	
25														*C*	
27															*C*

Figure 7. Water temperature comparisons matrix for 15 Missouri River study segments where water temperature was measured in 1997. A box with a letter in it means that those segments are not statistically different from each other. N = natural or least-impacted segments, **I** = inter-reservoir segments, and *C* = channelized segments. *C*, **I**, and N indicate where two channelized, inter-reservoir, or least-impacted segments are not different from each other. An X indicates 2 segments not otherwise grouped are statistically the same.

Conductivity

Conductivity (μS/cm) differed significantly among segments (P = 0.0001), but not macrohabitats (P = 0.6426). However, there was a significant interaction between segments and macrohabitats (P = 0.0001). Conductivity was higher in CHXOs, OSBs, ISBs, and SCC in channelized segments (Figure 8), and exhibited the greatest increase in these macrohabitats in the transition area between inter-reservoir and channelized segments. In general, TRM conductivities were lower in channelized segments than in natural or inter-reservoir segments. Tributary mouths had the highest average conductivity (682.69 μS/cm) across segments, whereas SCC had the lowest (613 μS/cm). Other macrohabitats had intermediate average conductivities. Generally, most inter-reservoir segments were not significantly (P < 0.05) different from each other (Figure 9). Mean conductivities decreased across segments in the following order; **14** (853.53 μS/cm), **15** (848.41 μS/cm), *17* (797.61 μS/cm), *19* (796.83 μS/cm), *23* (748.67 μS/cm), *27* (748.14 μS/cm), *25* (746.65 μS/cm), *22* (719.79 μS/cm), **7** (629.42 μS/cm), **8** (627.24 μS/cm), 9 (557 μS/cm), **12** (529.33 μS/cm), **10** (495.74 μS/cm), 3 (436.02 μS/cm), and 5 (397.14 μS/cm).

Conductivity

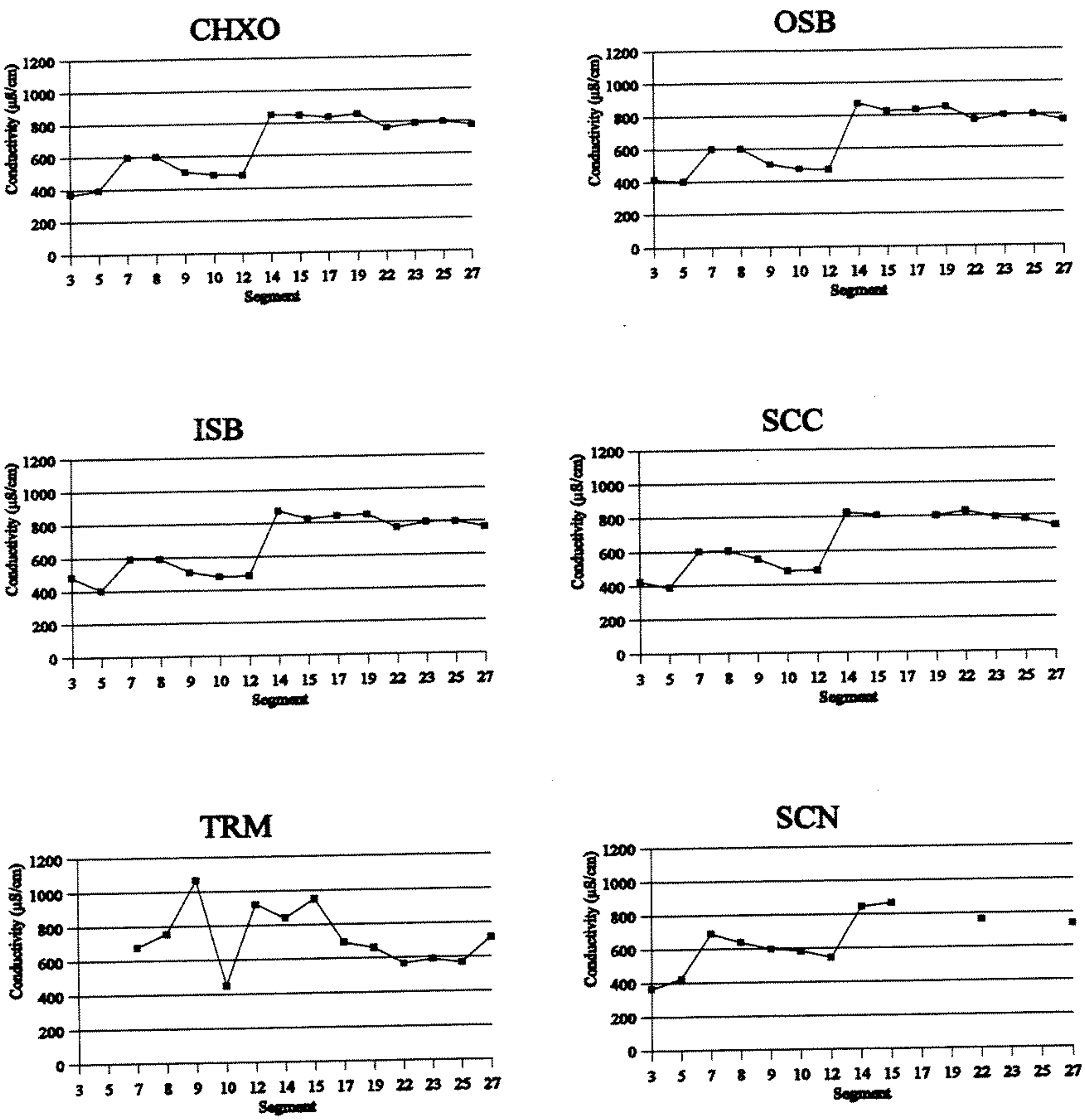


Figure 8. Average conductivity (µS/cm) in Missouri and Yellowstone (segment 9) River study segments measured in 1997 in six macrohabitats. CHXO-channel crossover, OSB-outside bend, ISB-inside bend, SCC-secondary channel connected, TRM-tributary mouth, SCN=secondary channel non-conected. Least-impacted segments: 3, 5, and 9; Inter-reservoir segments: 7, 8, 10, 12, 14, and 15; Channelized segments: 17, 19, 22, 23, 25, and 27.

	3	5	7	8	9	10	12	14	15	17	19	22	23	25	27
3	N	N													
5		N													
7			I	I											
8				I											
9					N		X								
10						I	I								
12							I								
14								I	I	X					
15									I	X	X				
17										C	C		C		C
19											C		C		C
22												C	C	C	C
23													C	C	C
25														C	C
27															C

Figure 9. Conductivity comparisons matrix for 15 Missouri River study segments where conductivity was measured in 1997. A box with a letter in it means that those segments are not statistically different from each other. N = natural or least-impacted segments, **I** = inter-reservoir segments, and *C* = channelized segments. *C*, **I**, and N indicate where two channelized, inter-reservoir, or least-impacted segments are not different from each other. An X indicates 2 segments not otherwise grouped are statistically the same.

Turbidity

Turbidity (log transformed NTU's) differed significantly among segments (P = 0.0001), but not macrohabitats (P = 0.2621). The interaction term was significant (P = 0.0007). Turbidity generally increased in CHXOs, OSBs, ISBs, and SCC from river segments 3 to 10. Segment 12 showed a sharp decrease in all macrohabitats and remained low through segment 15. Segment 17 began a gradual increase again. Average segment turbidities followed the same pattern with gradual downstream increases interrupted by extremely low turbidities in the lower inter-reservoir segments. Secondary channels: non connected and TRMs displayed no turbidity trends across segments. Comparisons among segments exhibited few generalized patterns (Figure 10). Segments **12** ($\bar{x}$= 7.2 NTUs) and **14** ($\bar{x}$= 6.0 NTUs) had the lowest segment average turbidities, and were the only inter-reservoir segments that were not different from each other. Turbidity (NTUs) decreased in the following segment order: **10** ($\bar{x}$=147.3), 9 ($\bar{x}$=88.0), *22* ($\bar{x}$=75.8), *23* ($\bar{x}$=69.4), *27* ($\bar{x}$=64.4), *25* ($\bar{x}$=49.0), **8** ($\bar{x}$=48.8), *19* ($\bar{x}$=43.2), 5 ($\bar{x}$=32.7), 3 ($\bar{x}$=31.7), *17* ($\bar{x}$=28.7), **15** ($\bar{x}$=27.5), **7** ($\bar{x}$=17.3), **12** ($\bar{x}$=8.4), and **14** ($\bar{x}$=17.3). Segments **12, 14**, and **15** are immediately downstream from reservoirs (Figure 11).

Turbidity

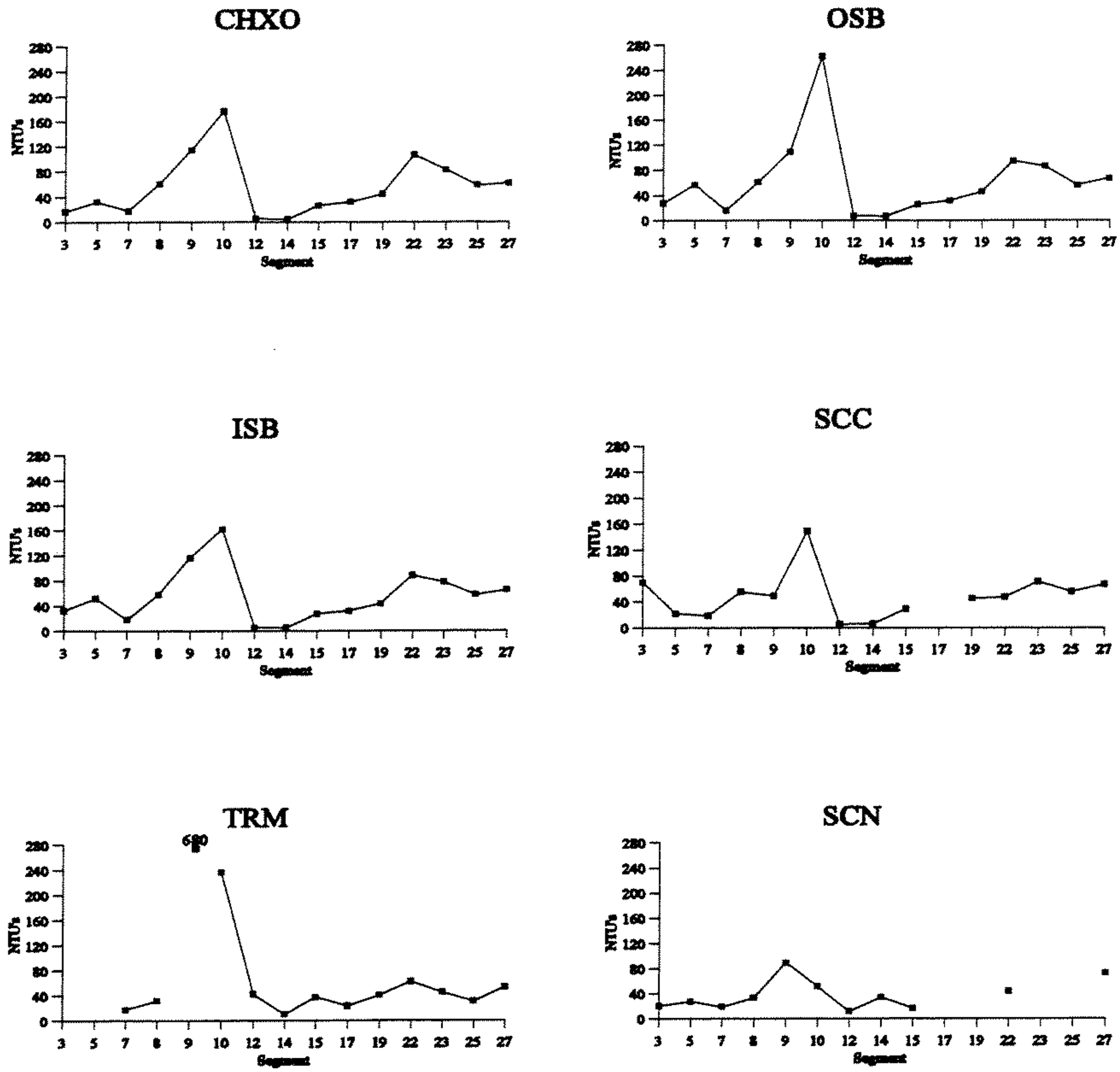


Figure 10. Average turbidity (NTU's) in macrohabitats of the Missouri and Yellowstone (9) Rivers study segments. CHXO=channel crossover; OSB=outside bend; ISB=inside bend; SCC=secondary channel connected; TRM=tributary mouth; SCN=secondary channel non-connected. Least-impacted segments: 3, 5, and 9; Inter-reservoir segments: 7, 8, 10, 12, 14, and 15; Channelized segments: 17, 19, 22, 23, 25, and 27.

	3	5	**6**	**7**	**8**	9	**10**	**12**	**14**	**15**	17	18	19	21	22	23	25	27
3	N	N								X	X		X					
5		N								X	X		X					
6			**I**															
7				**I**														
8					**I**								X				X	X
9						N									X	X		X
10							**I**											
12								**I**	**I**									
14									**I**									
15										**I**	X							
17											C							
18												C						
19													C				C	
21														C				
22															C	C		C
23																C		C
25																	C	C
27																		C

Figure 11. Turbidity comparisons matrix for 18 Missouri River study segments where turbidity was measured in 1997. A box with a letter in it means that those segments are not statistically different from each other. N=natural or least-impacted segments, **I**=inter-reservoir segments, and C=channelized segments. C, **I**, and N indicate where two channelized, inter-reservoir, or least-impacted segments are not different from each other. An X indicates 2 segments not otherwise grouped are statistically the same.

Substrate

The percentage of substrates composed of **gravel** (arc-sine of the square root transformed proportion) was significantly different among macrohabitats (P = 0.0001), segments (P = 0.0001), and the interaction term was also significant (P = 0.0394). At the 0.05 significance level, gravel substrates in OSB and CHXO differed from each other and from all other macrohabitats, ISB gravel substrates differed from all others except SCC, SCC gravel substrates differed from all others except ISB, SCN gravel substrates differed from all others except TRM, and TRM gravel substrates differed from all others except SCN (Figure 12). Gravel percentages by macrohabitat decreased in the following order: OSB ($\bar{x}$=20.0%), CHXO ($\bar{x}$=16.1%), ISB ($\bar{x}$=9.6%), SCC ($\bar{x}$=8.5%), SCN ($\bar{x}$=0.8%), and TRM ($\bar{x}$=0.2%). Least-impacted, upriver segments generally had higher gravel percentages than inter-reservoir and channelized, down-river segments (Figure 13). TRM and SCN habitats had little if any gravel component. The percent of substrate composed of gravel decreased by segment in the following order: 3 ($\bar{x}$=66.4%), 5 ($\bar{x}$=31.0%), 9 ($\bar{x}$=18.8%), *19* ($\bar{x}$=9.6%), *27* ($\bar{x}$=8.6%), **15** ($\bar{x}$=7.8%), **7** ($\bar{x}$=6.6%), **14** ($\bar{x}$=5.0%), *17* ($\bar{x}$=4.6%), **12** ($\bar{x}$=3.7%), *22* ($\bar{x}$=3.6%), **10** ($\bar{x}$=2.3%), *23* ($\bar{x}$=2.2%), *25* ($\bar{x}$=1.4%), and **8** ($\bar{x}$=0.4%).

The percentage of substrates composed of **sand** (arc-sine of the square root transformed proportion) was significantly different among segments (P = 0.0001), macrohabitats (P = 0.0001), and the interaction term was also significant (P = 0.0001). At the 0.05 significance level, sand substrates in CHXO differed from all other macrohabitats, OSB, ISB, and SCC sand substrates did not differ from each other, but did differ from the other three macrohabitats, and SCN and TRM habitats did not differ from each other, but did differ from the other four macrohabitats. Sand substrate percentages erratically increased in CHXO and OSB macrohabitats from upper to lower river segments (Figure14). Other macrohabitats showed no discernable trends. Sand percentages by macrohabitat decreased in the following order: CHXO ($\bar{x}$=83.3%), OSB ($\bar{x}$=68.3%), ISB ($\bar{x}$=66.7%), SCC ($\bar{x}$=61.4%), SCN ($\bar{x}$=14.2%), and TRM ($\bar{x}$=9.2%). Sand was the dominant substrate in all segments and provided little differentiation between segments (Figure 15). The percent of substrate composed of sand decreased by segment in the following order: **10** ($\bar{x}$=73.5%), *17* ($\bar{x}$=69.1%), **15** ($\bar{x}$=62.8%), *25* ($\bar{x}$=62.6%), *23* ($\bar{x}$=61.4%), **8** ($\bar{x}$=59.1%), **14** ($\bar{x}$=57.6%), **12** ($\bar{x}$=55.7%), *19* ($\bar{x}$=55.3%), **7** ($\bar{x}$=53.8%), *27* ($\bar{x}$=53.4%), *22*

($\bar{x}$=44.8%), 9 ($\bar{x}$=34.0%), 5 ($\bar{x}$=31.1%), and 3 ($\bar{x}$=22.3%).

The percentage of substrates composed of **silt** (arcsin of the square root transformed proportion) was significantly different among segments (P = 0.0001), macrohabitats (P = 0.0001), and the interaction term was also significant (P = 0.0001). At the 0.05 significance level, sand substrates in CHXO and OSB significantly differed from each other and all other macrohabitats. ISB, and SCC silt substrates did not differ from each other, but did differ from the other four macrohabitats, and SCN and TRM sand substrates did not differ from each other, but did differ from the other four macrohabitats (Figure16). Silt percentages by macrohabitat decreased in the following order: TRM ($\bar{x}$=89.4%), SCN ($\bar{x}$=84.2%), SCC ($\bar{x}$=26.6%), ISB ($\bar{x}$=20.6%), OSB ($\bar{x}$=4.4%), and CHXO ($\bar{x}$=0.2%). There were no trends of increase or decrease in silt percentages from the upper to lower river (Figure 17). Substrates in SCN and TRM habitats were generally dominated by silt and CHXO and OSB habitats were practically void of silt. The percent of substrate composed of silt decreased by segment in the following order: *22* ($\bar{x}$=51.5%), *27* ($\bar{x}$=43.0%), **12** ($\bar{x}$=39.9%), **8** ($\bar{x}$=39.6%), 9 ($\bar{x}$=38.3%), **7** ($\bar{x}$=37.2%), *23* ($\bar{x}$=33.7%), *25* ($\bar{x}$=33.6%), *19* ($\bar{x}$=33.1%), 5 ($\bar{x}$=32.9%), **14** ($\bar{x}$=32.9%), *17* ($\bar{x}$=24.7%), **15** ($\bar{x}$=23.5%), **10** ($\bar{x}$=23.0%), and 3 ($\bar{x}$=20.2%). The percent of cobble substrate was determined, but data are not available for this report.

Gravel Substrate

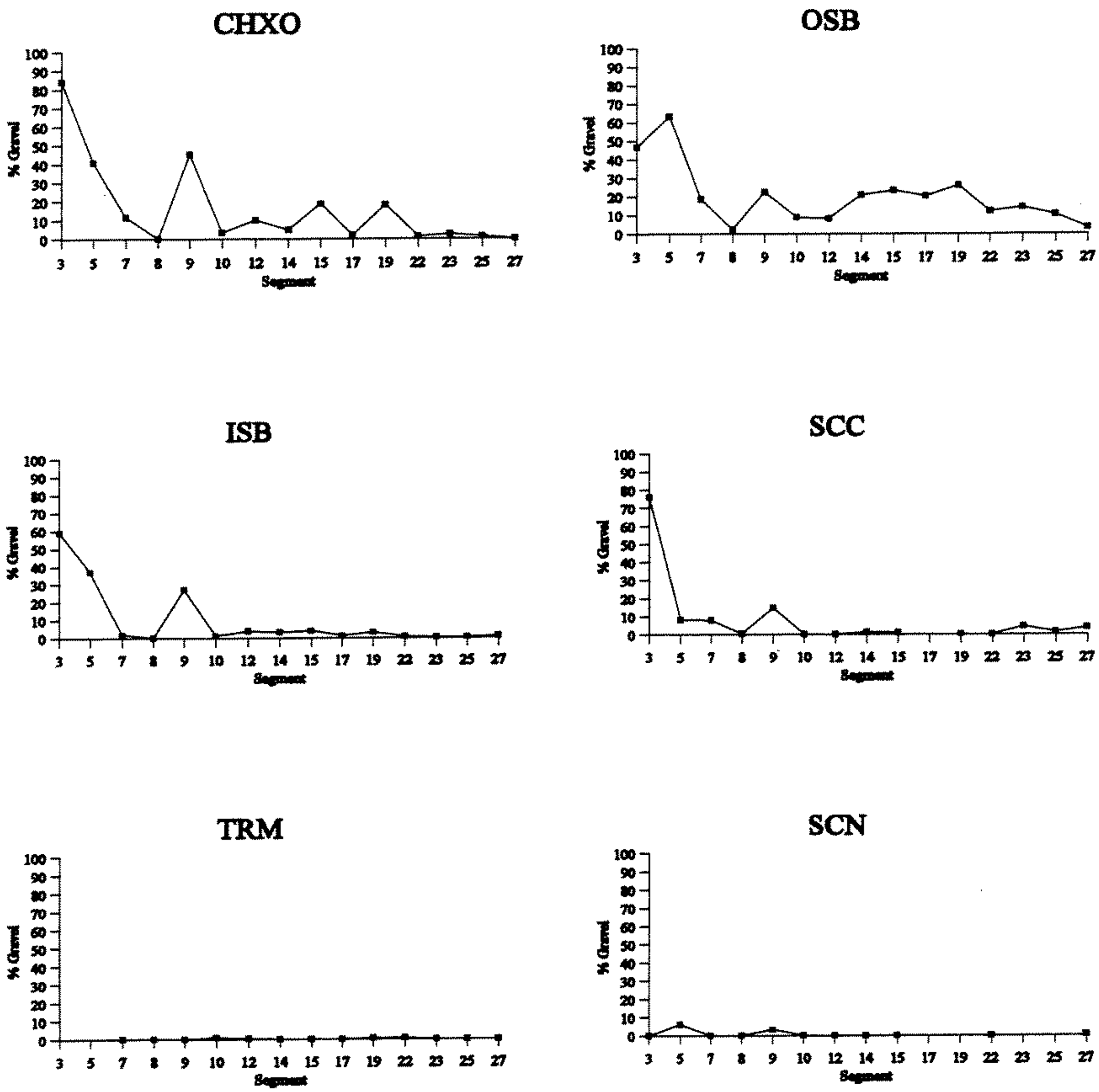


Figure 12. Proportional gravel substrate occurrence in Missouri and Yellowstone (9) study segments. Percentages are a proportional representation of the occurrence of gravel in relation to sand and silt-clay. CHXO=channel crossover; OSB=outside bend; ISB=inside bend; SCC=secondary channel connected; TRM=tributary mouth; SCN=secondary channel non-connected. Least-impacted segments: 3, 5, and 9; Inter-reservoir segments: 7, 8, 10, 12, 14, and 15; Channelized segments: 17, 19, 22, 23, 25, and 27.

	3	5	7	8	9	10	12	14	15	17	19	22	23	25	27
3	N														
5		N			N										
7			I			I	I	I	I	X	X	X	X	X	X
8				I		I	I					X	X	X	X
9					N										
10						I	I	I	I	X		X	X	X	X
12							I	I	I	X	X	X	X	X	X
14								I	I	X	X	X	X	X	X
15									I	X	X	X	X	X	X
17										C	C	C	C	C	C
19											C		C		
22												C	C	C	C
23													C	C	C
25														C	C
27															C

Figure 13. Gravel comparisons matrix for 15 Missouri River study segments where gravel was measured in 1997. A box with a letter in it means that those segments are not statistically different from each other. N=natural or least-impacted segments, I=inter-reservoir segments, and C=channelized segments. C, I, and N indicate where two channelized, inter-reservoir, or least-impacted segments are not different from each other. An X indicates 2 segments not otherwise grouped are statistically the same.

Sand Substrate

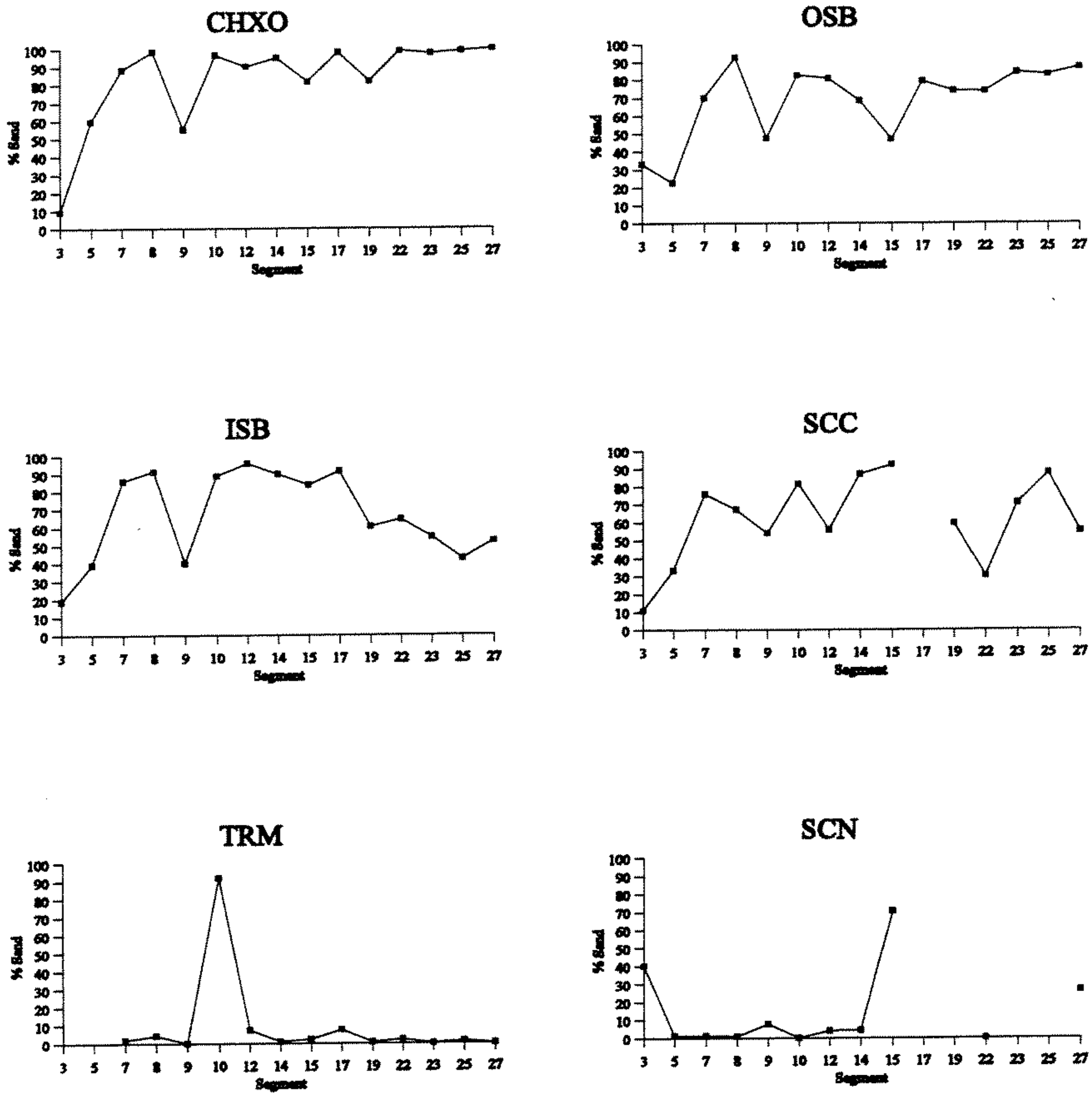


Figure 14. Proportional sand substrate occurrence in Missouri and Yellowstone (9) study segments. Percentages are a proportional representation of the occurrence of sand in relation to gravel and silt-clay. CHXO=channel crossover; OSB=outside bend; ISB=inside bend; SCC=secondary channel connected; TRM=tributary mouth; SCN=secondary channel non-connected. Least-impacted segments: 3, 5, and 9; Inter-reservoir segments: 7, 8, 10, 12, 14, and 15; Channelized segments: 17, 19, 22, 23, 25, and 27.

	3	5	**7**	**8**	9	**10**	**12**	**14**	**15**	17	19	22	23	25	27
3	N														
5		N			N							X			
7			**I**	**I**	X		**I**				X	X	X	X	X
8				**I**		**I**	**I**	**I**	**I**	X	X		X	X	X
9					N						X	X			
10						**I**	**I**	**I**	**I**	X				X	
12							**I**	**I**	**I**	X	X		X	X	X
14								**I**	**I**	X			X	X	X
15									**I**	X				X	
17										C			C	C	C
19											C	C	C		C
22												C	C		C
23													C	C	C
25														C	C
27															C

Figure 15 . Sand comparisons matrix for 15 Missouri River study segments where turbidity was measured in 1997. A box with a letter in it means that those segments are not statistically different from each other. N=natural or least-impacted segments, **I**=inter-reservoir segments, and C=channelized segments. C, **I**, and N indicate where two channelized, inter-reservoir, or least-impacted segments are not different from each other. An X indicates 2 segments not otherwise grouped are statistically the same.

Silt-Clay Substrate

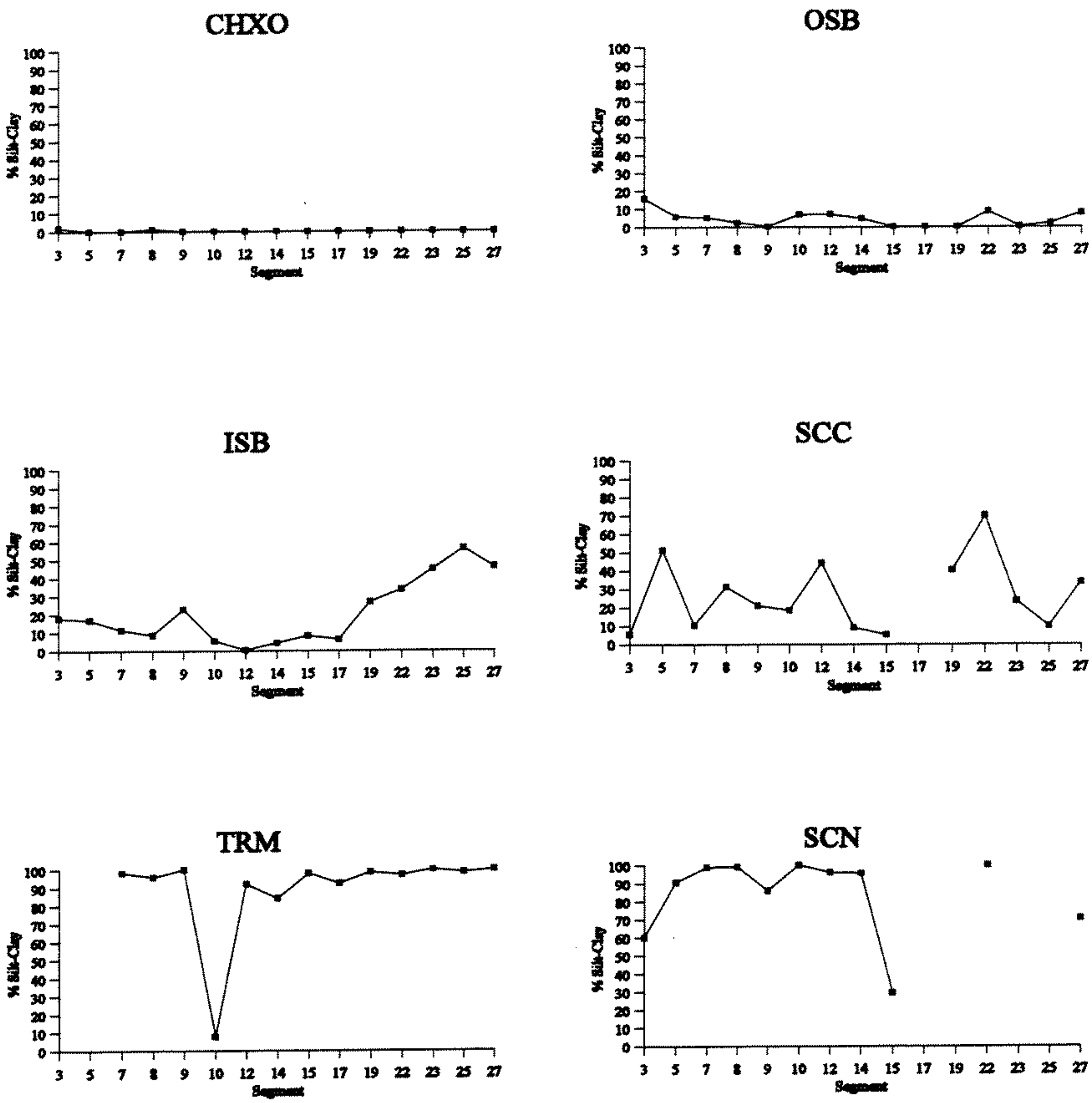
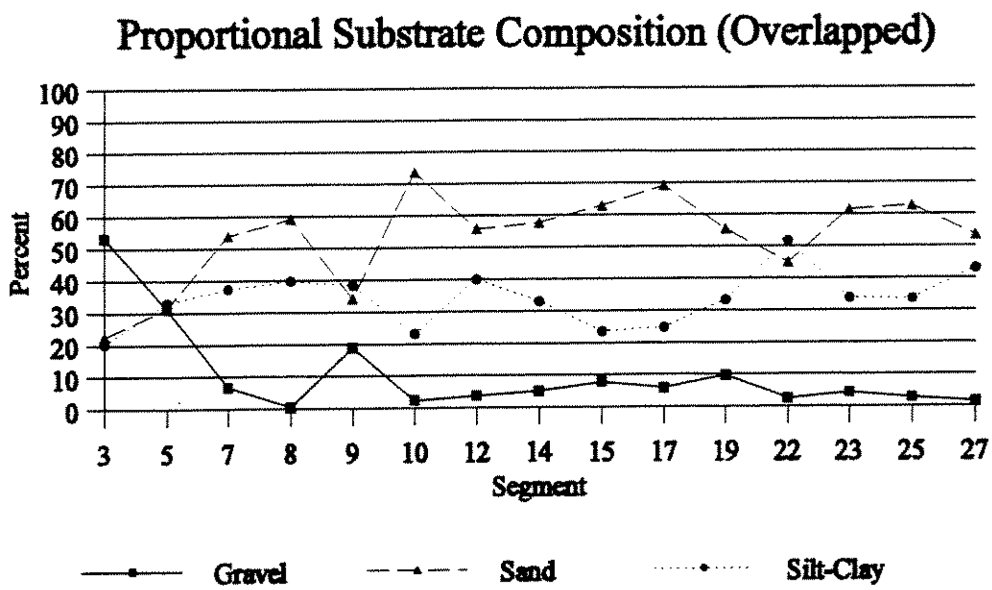


Figure 16. Proportional silt-clay substrate occurrence in Missouri and Yellowstone (9) study segments. Percentages are a proportional representation of the occurrence of silt-clay in relation to gravel and sand. CHXO=channel crossover; OSB=outside bend; ISB=inside bend; SCC=secondary channel connected; TRM=tributary mouth; SCN=secondary channel non-connected. Least-impacted segments: 3, 5, and 9; Inter-reservoir segments: 7, 8, 10, 12, 14, and 15; Channelized segments: 17, 19, 22, 23, 25, and 27.

	3	5	**7**	**8**	9	**10**	**12**	**14**	**15**	17	19	22	23	25	27
3	N					X		X	X	X					
5		N	X	X	N	X	X	X		X	X		X	X	
7			**I**	**I**	X		**I**				X		X	X	X
8				**I**			**I**				X	X	X	X	X
9					N	X	X	X		X	X		X	X	
10						**I**	**I**	**I**	**I**	X	X			X	
12							**I**	**I**		X	X		X	X	X
14								**I**	**I**	X	X				
15									**I**	X					
17										C	C				
19											C		C	C	C
22												C			C
23													C	C	C
25														C	C
27															C

Figure 17. Silt-clay comparisons matrix for 15 Missouri River study segments where turbidity was measured in 1997. A box with a letter in it means that those segments are not statistically different from each other. N=natural or least-impacted segments, **I**=inter-reservoir segments, and C=channelized segments. C, **I**, and N indicate where two channelized, inter-reservoir, or least-impacted segments are not different from each other. An X indicates 2 segments not otherwise grouped are statistically the same.



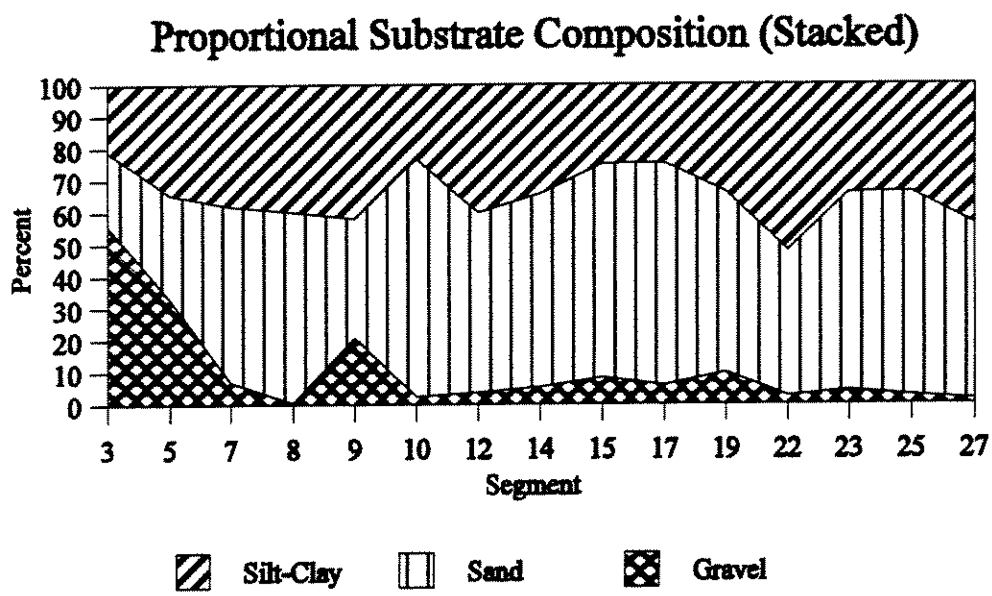
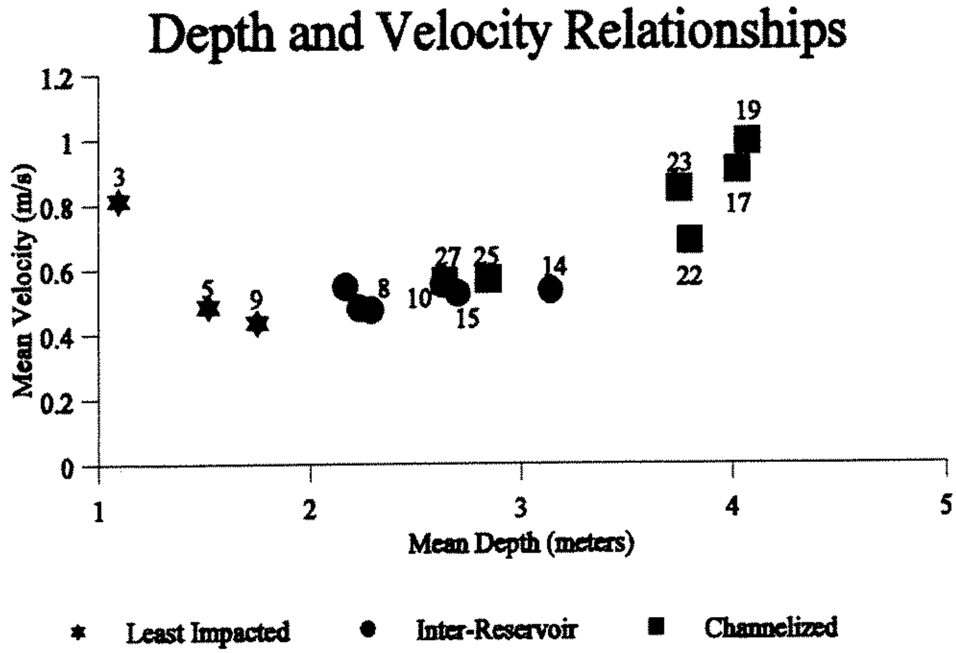


Figure 18. Average segment substrate proportions in Missouri and Yellowstone (9) study segments. Percentages are a proportional representation of the occurrence of each substrate in relation to the others. Top graph contains overlapping proportional percentage data for each substrate type. Bottom graph stacks the three substrate types to show the fractionation of the three substrate types. Least-impacted segments: 3, 5, and 9; Inter-reservoir segments: 7, 8, 10, 12, 14, and 15; Channelized segments: 17, 19, 22, 23, 25, and 27.



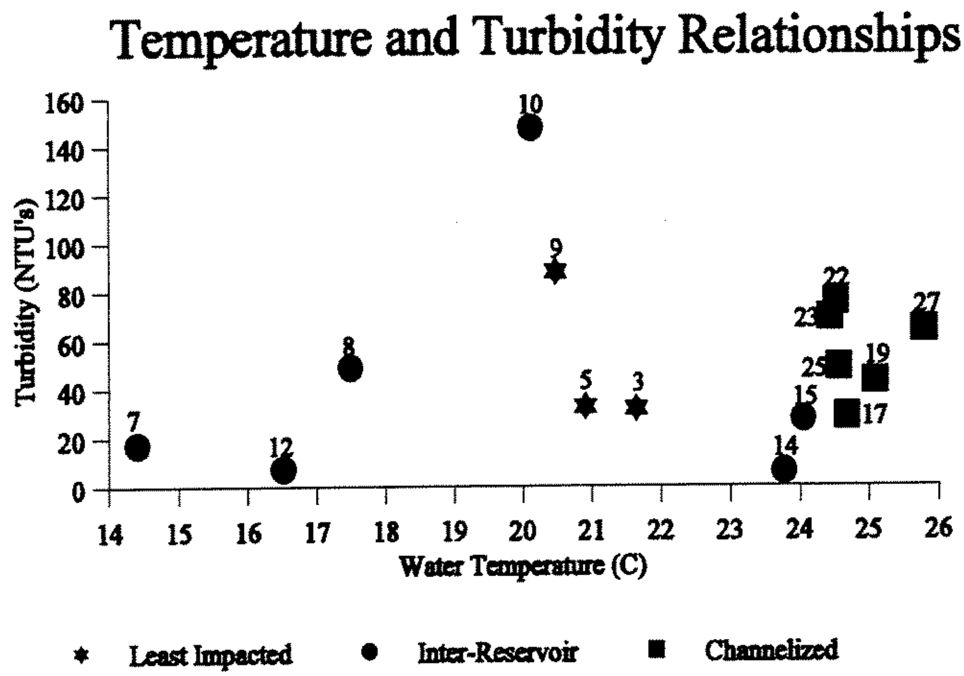


Figure 19. Segment averaged values for physical habitat (depth and velocity) and water quality (temperature and turbidity) variables collected from the Missouri and Yellowstone (9) study segments.

Habitat Data Summary

Comparisons of physical habitat characteristics (depth, velocity, water temperature, conductivity, turbidity, and substrate) showed significant segment differences and interactions for all metrics, but comparisons among macrohabitats were only significant for depth, velocity, and substrate measurements. Depth showed a gradual increase from upstream to downstream in the three main channel macrohabitats (CHXO, OSB, and ISB), while the other three macrohabitats showed no patterns. Velocity measurements fluctuated more in the channelized segments than in other segments. For example, segments *17* and *19* (Iowa/Nebraska) showed peaks of high velocity in CHXO and OSB macrohabitats. Channelized segment velocities in CHXO and OSB macrohabitats slowed gradually further downstream, but were always higher than in all the non-channelized segments. Water temperature gradually increased from upstream to downstream among all macrohabitats, except at segments **7** (Fort Peck tailwater) and **12** (between Lake Sakakawea and Lake Oahe) where depressions in the temperature trend line occurred. Conductivity ranged between 400 and 600 μS/cm in CHXO, OSB, ISB, and SCC macrohabitats from segment 3 to segment **12**. From segment **14** to the confluence, measurements increased to values between 750 and 900 μS/cm. Turbidity increased from segment 3 ($\bar{x}$ =31.7 NTU's) to segment **10** ($\bar{x}$ =147.3 NTU's) in all flowing macrohabitats (CHXO, OSB, ISB, and SCC). Turbidity values then dropped to less than 10 NTU's in segments **12** and **14**. From segment **15** to the mouth, turbidity gradually returned to between 40 to 90 NTU's. Substrate was dominated by sand in all inter-reservoir and channelized segments, but gravel formed a much higher proportion of the total substrate composition in the least-impacted segments (Figure 18). Plotting depth and velocity together (Figure 19) illustrated that channelized segments *17, 19, 22*, and *23* were both deeper and faster than all the other segments. When temperature was plotted against turbidity, the channelized segments grouped, the least-impacted segments also grouped, but inter-reservoir segments were scattered (Figure 19). Inter-reservoir segments were the coldest, with the exception of segments **14** and **15**, the last two inter-reservoir segments. They were even colder than least-impacted segments in Montana. Segments were grouped differently depending upon the physical variable examined. Very few segments were grouped together when all physical habitat data was combined.

Fieldwork: Fish Sampling

During 1997 we collected 56,185 fishes (Table 9) from reaches that represented 1,150 miles of riverine habitat, or 80% of the total river exclusive of reservoirs (Table 1). The catch was about two times that caught in 1996, primarily because of increased sampling effort. All 26 species of benthic fish that are the focus of this study were captured. The most commonly collected fishes in the benthic fish guild were emerald shiner (12%), *Hybognathus* spp. (10%), flathead chub (9%), river carpsucker (6%), channel catfish (4%), common carp (2%), and freshwater drum (2%). Following are some general observations for the 1997-sampling year:

- High water in upper segments connected more oxbows to the river than in 1996, and the oxbows held many benthic fish like blue suckers, channel catfish, and both buffalo species.
- Flathead chubs were collected for the first time in the Iowa segments
- The Kansas Unit caught 22 shovelnose sturgeon in one gill net, and found logperch and stonecats for the first time
- Twenty of 26 target species including a pallid sturgeon were found in Segment 10 in North Dakota
- In Montana, 160 sicklefin chubs were collected in 1997 compared to 33 in Montana in 1996 and 83 for all sections combined in 1996
- In Montana, sturgeon chub catches increased from 315 to 503; over 1,500 flathead chubs were collected; new records were for shortnose gar and brook stickleback
- Two juvenile blue suckers were captured below tributaries in South Dakota, thus indicating successful recent spawning of this species
- A 45-lb flathead catfish was collected by electrofishing in a tributary mouth in South Dakota
- 25 more species were collected in the Missouri segments in 1997 than in 1996 including two target species (shorthead redhorse, blue sucker)

The catch in 1997 was comprised of 93 taxa, compared to 78 species found in 1996. A notable addition to the species list was the pallid sturgeon, which was collected at the mouth of the Yellowstone River. Other new species include five shiners (bigeye, striped, mimic, silverband, common), black buffalo, chestnut lamprey, freckled madtom, lake whitefish, lake sturgeon, largescale stoneroller, logperch, muskellunge, skipjack herring, and yellow bass. No new introduced species were found. Hybrids were rarely found (22 fish) and were mostly centrarchids and sauger-walleye. About 2% of the fish could not be identified to species because of their small size. This was a great improvement over the 9% unidentified in 1996.

Some changes in the fish community metrics were apparent among river segments. Species richness increased in a fairly regular fashion from 27 species in the upper river to 54 species in lower river segments (Table 9). Segments 7 and 8 (between the Milk and Yellowstone rivers in Montana) were the only segments where the catch fell below 1,500 fish. Emerald shiner and fish in the genus *Hybognathus* were common throughout the river, making up >10% of the sample at nine (emerald shiner) and six (*Hybognathus*) of our 17 study segments (Table 10). Flathead chubs and goldeye were dominant components in the catch above Lake Sakakawea whereas gizzard shad made up as much as 62% of the sample in seven segments downstream from Lake Sakakawea. River carpsucker and channel catfish sometimes comprised >10% of the sample in the lower river, but never reached this proportion of the total sample in upstream segments. These general trends were also found in 1996.

Following is a brief presentation of the findings for each species in 1997 with a cursory comparison with similar data collected in 1996. Our preliminary interpretation is that the data from both years are very similar and lead to similar conclusions about the benthic fish populations as characterized by their distribution, relative abundance, habitat association, and gear vulnerability.

Table 9. Total numbers of all fishes collected in each Missouri River and Lower Yellowstone Study Segments in 1997. Columns in bold font represent segments between and immediately downstream from impoundments.

State	MT					ND		SD		IA/NE		KS/MO			MO	
Segment	3	5	**7**	**8**	9	**10**	**12**	**14**	**15**	17	19	22	23	25	27	Total
Target Benthic Fish																
Bigmouth buffalo		2	**1**	**97**		**112**	**32**	**2**	**14**	15	7	2	1	5		290
Blue catfish												20	33	12	22	87
Blue sucker	3	3	**6**	**1**	6		**1**		**15**	31	7	11	11	1		96
Brassy minnow								**1**	**13**							14
Burbot	3	66		**1**	2	**13**		**1**	**1**							87
Channel catfish	28	124	**22**	**42**	190	**67**	**16**	**210**	**161**	112	47	210	374	173	333	2109
Common carp	62	63	**20**	**209**	8	**29**	**46**	**137**	**176**	20	59	90	98	113	105	1235
Emerald shiner	343	636	**1**		143	**28**		**241**	**1598**	204	514	647	685	1175	676	6891
Fathead minnow			**102**		2		**84**	**5**	**7**	5	9	3	1	1		219
Flathead catfish								**2**	**57**	42	61	74	80	32	50	398
Flathead chub	509	1360	**69**	**124**	2602	**371**		**4**	**7**	1	1	2	2	1	1	5054
Freshwater drum	69	44	**1**	**2**	2	**2**		**7**	**70**	5	17	331	186	95	115	946
Hybognathus spp.	64	1559	**15**	**8**	716					23	227	342	397	1784	301	5436
Pallid sturgeon						**1**										1
Plains minnow			**2**			**20**								14	1	37
River carpsucker	17	54	**36**	**23**	135	**44**	**24**	**72**	**181**	38	483	151	59	1286	915	3518
Sand shiner								**7**	**236**	27	1	4	1	5	85	366
Sauger	16	36	**6**	**7**	10	**30**	**3**	**11**	**10**	15	21	17	6	11	4	203
Shorthead redhorse	114	121	**8**	**29**	13	**6**	**13**	**3**	**149**	33			6	4	3	502
Shovelnose sturgeon	16	55	**43**	**22**	93	**20**	**6**	**4**	**11**	78	24	68	63	43	19	565
Sicklefin chub		109		**18**	34	**7**						3	4	13	24	212
Smallmouth buffalo	3		**4**	**34**	6	**45**	**1**	**10**	**93**	12	2	6	8	18	28	270
Stonecat	2	71	**2**	**4**	39	**5**		**3**				2	2			130
Sturgeon chub		161	**9**	**48**	285	**17**				2		4	11	8	1	546
Walleye	11	23	**5**	**45**	10	**16**	**23**	**38**	**137**	12	8	1	2		2	333

Table 9. Continued

State	MT--				-ND-		-SD-		-IA/NE-		-KS/MO-			-MO	
Segment	3	5	**7**	**8**	9	**10**	**12**	**14**	**15**	17	19	22	23	25	27	Total
Western silvery minnow			**8**	**2**	5	**280**										295
White sucker	44	2	**64**	**45**		**1**	**1108**	**1**	**1**							1266
Non-Target Fish (excluding hybrids and introduced species)																
Bigeye shiner												1			1	2
Bigmouth shiner									**50**	15				13	5	83
Black buffalo													2			2
Black bullhead						**1**		**3**								4
Black Crappie	1	52						**2**	**7**	2	2	5		5		76
Bluegill								**3**	**12**	28	11	67	53	124	81	379
Bluntnose minnow									**1**					6	13	20
Brook silverside											6			1	1	8
Brook stickleback				**1**												1
Bullhead minnow												2		1	3	6
Chestnut lamprey														2		2
Common shiner															2	2
Creek chub					3		**1**					2				6
Freckled madtom															3	3
Ghost shiner												1				1
Gizzard shad									**3264**	2175	1644	371	580	831	3700	12565
Golden shiner						**2**					1					3
Golden redhorse										1		2	14			17
Goldeye	43	206	**121**	**274**	133	**249**	**25**	**37**	**112**	221	77	34	50	33	50	1665
Green sunfish					2			**1**	**9**		2	55	48	9	9	135
Highfin carpsucker									**1**			1			2	4
Johnny darter							**7**	**35**	**16**	2	3				1	64

Table 9. Continued

State	MT--					-ND----------------		-SD----------------		-IA/NE------------		-KS/MO------------------------		-MO	
Segment	3	5	**7**	**8**	9	**10**	**12**	**14**	**15**	17	19	22	23	25	27	Total
Lake whitefish				**2**												2
Lake sturgeon														3	1	4
Largemouth bass								**49**	**24**	19	8	26	5	16	3	150
Largescale stoneroller														2		2
Logperch													1	4		5
Longnose sucker	129	9	**23**	**2**	2	**1**	**2383**									2549
Longnose dace	69	46	**3**	**12**	91	**4**										225
Longnose gar									**18**	2	3	4	15	13	15	70
Mimic shiner									**3**	2		3			57	65
Mottled sculpin	1	4														5
Muskellunge							**1**									1
Northern pike	3	20	**20**	**18**	8	**27**	**4**	**7**	**12**	3	2					124
Orangespotted sunfish									**2**		2	65	4	4	7	84
Paddlefish						**1**		**1**		2	1				1	6
Quillback								**21**	**642**	8	4	7	11	1	6	700
Rainbow trout	1		**3**													4
Red shiner							**4**	**19**	**144**	65	13	65	101	162	510	1083
River redhorse												1				1
River shiner								**1**	**166**	125	28	55	38	95	29	537
Rock bass								**6**	**8**							14
Shortnose gar					1				**19**	16	22	42	53	38	93	284
Silver chub										4	39	76	32	11	53	215
Silverband shiner												1			1	2
Skipjack herring													1	3	4	8

Table 9. Continued

State	MT------------------------------------				-ND-------------		-SD-------------		-IA/NE-----------		-KS/MO-----------------			-MO	
Segment	3	5	7	8	9	10	12	14	15	17	19	22	23	25	27	Total
Smallmouth bass	1							**77**	**138**	2						218
Speckled chub											23		13	39	176	251
Spotfin shiner								**513**	**554**	94	8		2			1171
Spottail shiner	5	81		**2**	1	**1**	**3**	**1**	**4**	2						100
Spotted bass													1	24	17	42
Spotted gar														1		1
Striped shiner															1	1
Suckermouth minnow													4		4	8
White crappie	4	54		**3**	6	**9**		**137**	**9**	3	5	18	5	9		262
Yellow bass															4	4
Yellow bullhead										1	2	1				4
Yellow perch	2	23				**1**	**6**	**289**	**118**	7						446
Introduced Species (excluding Common carp)																
Bighead carp														1	2	3
Chinook salmon			**1**													1
Ciscoe			**6**				**2**									8
Grass carp									**3**	1	2	1		2	1	10
Mosquitofish													8	6	101	115
Rainbow smelt							**14**	**1**	**1**					1		17
Striped bass													1	1	4	6
White bass				**2**				**9**	**94**	9	6	32	47	33	53	285
Hybrids																
Green sunfish x ?											1					1
Green sunfish x Bluegill											8					8

Table 9. Continued

State	MT---ND----------------SD------------------IA/NE------------KS/MO-----------------------MO														
Segment	3	5	**7**	**8**	9	**10**	**12**	**14**	**15**	17	19	22	23	25	27	Total
Green sunfish x orangespotted s.f.									**1**			1				2
Sauger x Walleye							**1**		**4**		5					10
Striped bass x White bass													1			1
Unidentified (Unid.) Species and Others																
Age 0 fish (YOY)					2								4			6
Unid. Buffalo	2															
Unid. Carpsucker										2						2
Unid. Chub						**5**								2		7
Unid. Minnow	46				1	**21**	**2**				1	70	61	7	16	225
Unid. Redhorse										1						1
Unid. Sucker	7			**1**	2	**156**	**86**		**4**	2		1				259
Unid. Sunfish												49	1			50
Unid. *Lepomis*						**1**						25				26
Unid. *Notropis*										29	212	1		1	4	247
Unid. *Stizostedion*				**6**		**34**	**1**									41
Unidentified fish	22	2												28		52
TOTAL	1643	4991	**601**	**1084**	4553	**1627**	**3897**	**1971**	**8377**	3518	3629	3073	3186	6326	7719	56185
Species Richness	27	27	**27**	**28**	28	**30**	**23**	**39**	**46**	43	40	46	45	52	54	93

Table 10. The five numerically dominant fish taxa, expressed as the percentage of total catch within each Missouri and Lower Yellowstone River study segment in 1997. Species in bold font are target benthic species.

Segment	Taxa(%)	% of Segment
3	**Flathead chub (31%)**	75%
	Emerald shiner (21%)	
	Longnose sucker (8%)	
	Shorthead redhorse(7%)	
	Freshwater drum and	
	Longnose dace (each 4%)	
5	**Hybognathus spp. (31%)**	79%
	Flathead chub (27%)	
	Emerald shiner (13%)	
	Goldeye (4%)	
	Sturgeon chub (3%)	
7	Goldeye (20%)	66%
	Fathead minnow (17%)	
	Flathead chub (11%)	
	White sucker (11%)	
	Shovelnose sturgeon (7%)	
8	Goldeye (25%)	69%
	Common carp (19%)	
	Flathead chub (11%)	
	Bigmouth buffalo (9%)	
	Sturgeon chub (4%)	
9	**Flathead chub (57%)**	86%
	Hybognathus spp. (16%)	
	Sturgeon chub (6%)	
	Channel catfish (4%)	
	Emerald shiner (3%)	
10	**Flathead chub (23%)**	66%
	W. silvery minnow (17%)	
	Goldeye (15%)	
	Bigmouth buffalo (7%)	
	Channel catfish (4%)	
12	Longnose sucker (61%)	94%
	White sucker (28%)	
	Fathead minnow (2%)	
	Bigmouth buffalo (1%)	
	Common carp (1%)	
14	Spotfin shiner (26%)	77%
	Yellow perch (15%)	
	Emerald shiner (12%)	
	Channel catfish (11%)	
	Common carp and	
	White crappie (each 7%)	
15	Gizzard shad (39%)	75%
	Emerald shiner (19%)	
	Quillback (8%)	
	Spotfin shiner (7%)	
	Sand shiner (3%)	
17	Gizzard Shad (62%)	81%
	Emerald shiner (6%)	
	Goldeye (6%)	
	Red shiner (4%)	
	Channel catfish (3%)	
19	Gizzard shad (45%)	81%
	Emerald shiner (14%)	
	River carpsucker (13%)	
	Hybognathus spp. (6%)	
	Goldeye (2%)	
22	**Emerald shiner (21%)**	62%
	Gizzard shad (12%)	
	Freshwater drum (11%)	
	Hybognathus spp. (11%)	
	Channel catfish (7%)	
23	**Emerald shiner (22%)**	70%
	Gizzard shad (18%)	
	Hybognathus spp. (12%)	
	Channel catfish (12%)	
	Freshwater drum (6%)	
25	**Hybognathus spp. (28%)**	83%
	River carpsucker (20%)	
	Emerald shiner (19%)	
	Gizzard shad (13%)	
	Channel catfish (3%)	
27	Gizzard shad (48%)	79%
	River carpsucker (12%)	
	Emerald shiner (9%)	
	Red shiner (7%)	
	Channel catfish (4%)	

Population Structure and Habitat Use of Benthic Fishes Taxa

A general format for population structure and habitat use of each benthic taxa includes a brief paragraph summarizing results, a table and figure of catch-per-unit-effort data by gear across macrohabitats and segments, a length frequency histogram of size structure, and a habitat use (depth, velocity, turbidity, and water temperature) figure. This format provides the reader with access to system-wide information about each target benthic taxa. Catch-per-unit-effort figures have a standardized range for the Y-axis to facilitate comparisons among macrohabitats. Size structure figures are the frequency of occurrence of each taxa's individuals plotted against species specific length intervals. Some size structure figures (emerald shiner, sand shiner, sicklefin chub, sturgeon chub, and flathead chub) show that a number (N) of fish were collected, but no length frequency data were given because length and weight was measured in the field at some river sections and not at others. When measurements were not taken in the field, the measurements were made in the laboratory before the fish were aged and were not available for this annual report. Habitat use figures are the frequency of occurrence of each taxa plotted against intervals of depth, velocity, turbidity, and water temperature.

Bigmouth buffalo (BMBF)

Bigmouth buffalo (n = 290) were captured throughout the river, but 88% were collected in inter-reservoir segments **7** through **15** (Table 9). The distribution in 1996 was similar but only 14 fish were captured. Fish ranged in length from fingerlings to over 900 mm, but representation across all size classes was not found in any section (Figure 21). For example, small fish that perhaps indicate successful spawning were found only in Sections 2, 4, and 5. Most bigmouth buffalo were caught in shallow, quiescent areas, and about half were caught where water temperature was 26-28 °C, otherwise, catch was similar throughout the temperature range (16 – 30 °C) in which fish were captured. (Figure 22). Most fish were caught by seining and electrofishing (Table 11, Figure 20), but a few were collected in stationary gill nets. This information on bigmouth buffalo agrees with that presented in 1996.

Bigmouth Buffalo

Table 11. Catch-Per-Unit-Effort (CPUE) for bigmouth buffalo by gear, across macrohabitats (CHXO=Channel Cross-Over, ISB=Inside Bend, OSB=Outside Bend, SCC=Secondary Channel Connected, SCN=Secondary Channel Non-Connected, and TRM=Tributary Mouth). Catch rates are reported as #fish/100m for benthic trawl (BT) and drifting trammel net (DTN), #fish/180 degree haul for a bag seine (BS), #fish/hr for a stationary gill net (SGN), and #fish/min for electrofishing (EF). Least-impacted segment numbers = standard font. Inter-reservoir segment numbers = bold font. Channelized segment numbers = italic font. A "-" indicates that no sample was taken.

Segment	CHXO		ISB					OSB			SCC				SCN			TRM			
	BT	DTN	BS	BT	DTN	EF	SGN	BT	DTN	EF	BS	BT	DTN	EF	BS	EF	SGN	BT	DTN	EF	SGN
3	-	0.00	-	-	0.00	0.00	-	-	0.00	0.00	-	-	0.00	0.00	-	-	0.00	-	-	-	-
5	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.02	-	-	-	-
7	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00	-	0.00	0.00	0.00	-	0.11	-	0.00	-	-	-	0.00
8	0.00	0.00	0.33	0.00	0.00	-	-	0.00	0.00	-	0.00	0.00	0.00	-	10.4	-	-	-	-	-	-
9	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00	-	0.00	0.00	0.00	-	0.00	-	-	-	-	-	-
10	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.05	-	1.36	0.00	0.00	0.00	0.00	-
12	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00	0.00	0.00	-	-	-	3.33	0.16	0.00	-	-	0.00	0.00
14	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	-	-	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	-	0.00	0.00	0.00	0.00	0.11	0.00	0.00	0.00	-	0.03	0.00	-	-	0.01	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	-	-	-	-	-	-	-	0.17	0.00
19	0.00	0.00	-	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	0.00	-	-	-	-	0.00	0.04	0.00
22	0.00	0.00	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	-	-	0.00	0.00	0.00	0.00	0.00	0.01	0.01
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	-	0.00	0.00	0.00	0.01
25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	-	0.00	0.00	0.03	0.00
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00

Bigmouth Buffalo

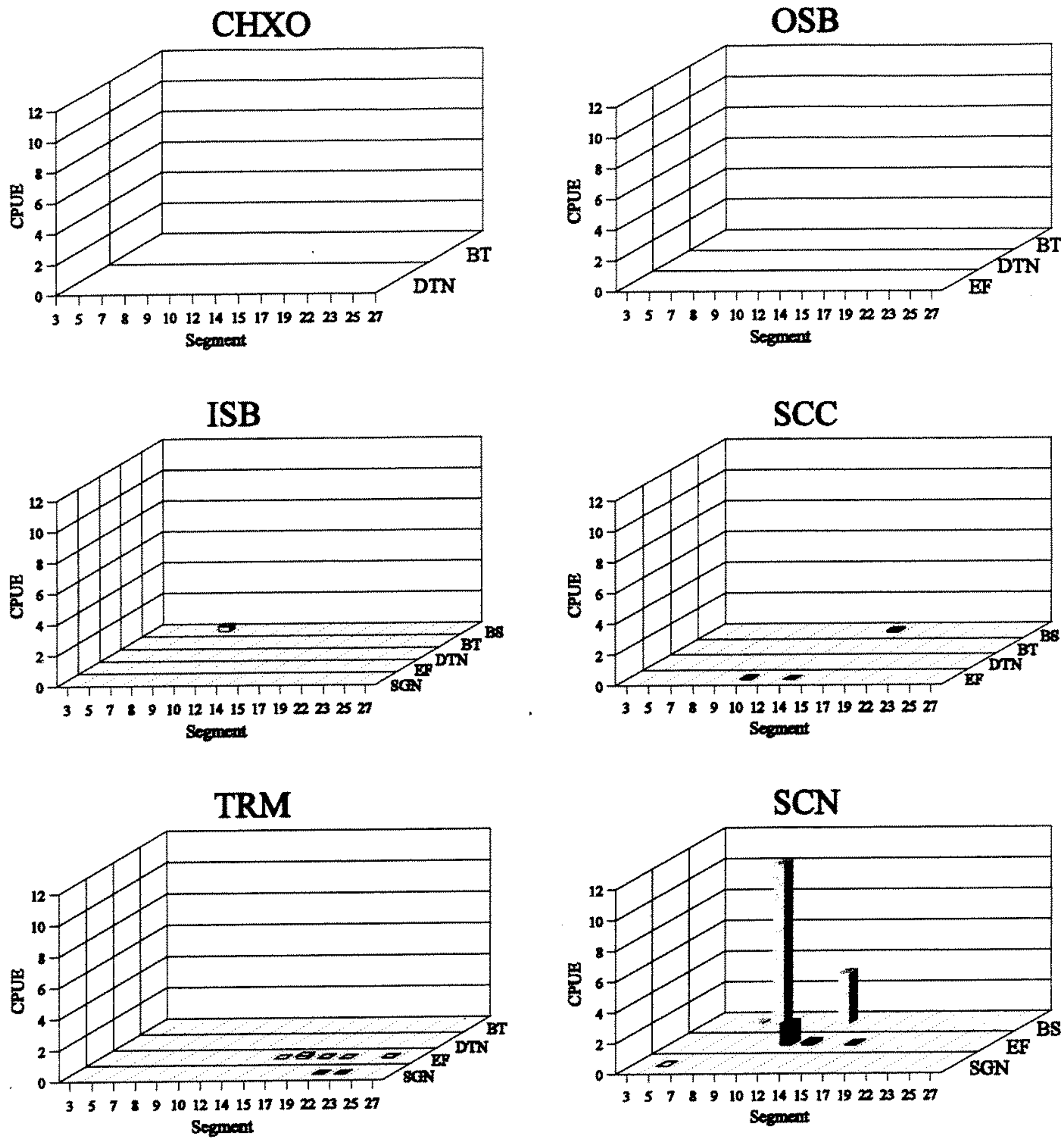


Figure 20. Trends of bigmouth buffalo catch rates among Missouri and Yellowstone River study segments and macrohabitats in 1997. Catch rates are reported as #fish/100m for benthic trawl (BT) and drifting trammel net (DTN), #fish/180 degree haul for a bag seine (BS), #fish/hr for a statinary gill net (SGN), and #fish/min for electrofishing (EF). See Appendix A for list of macrohabitat acronyms.

Bigmouth Buffalo

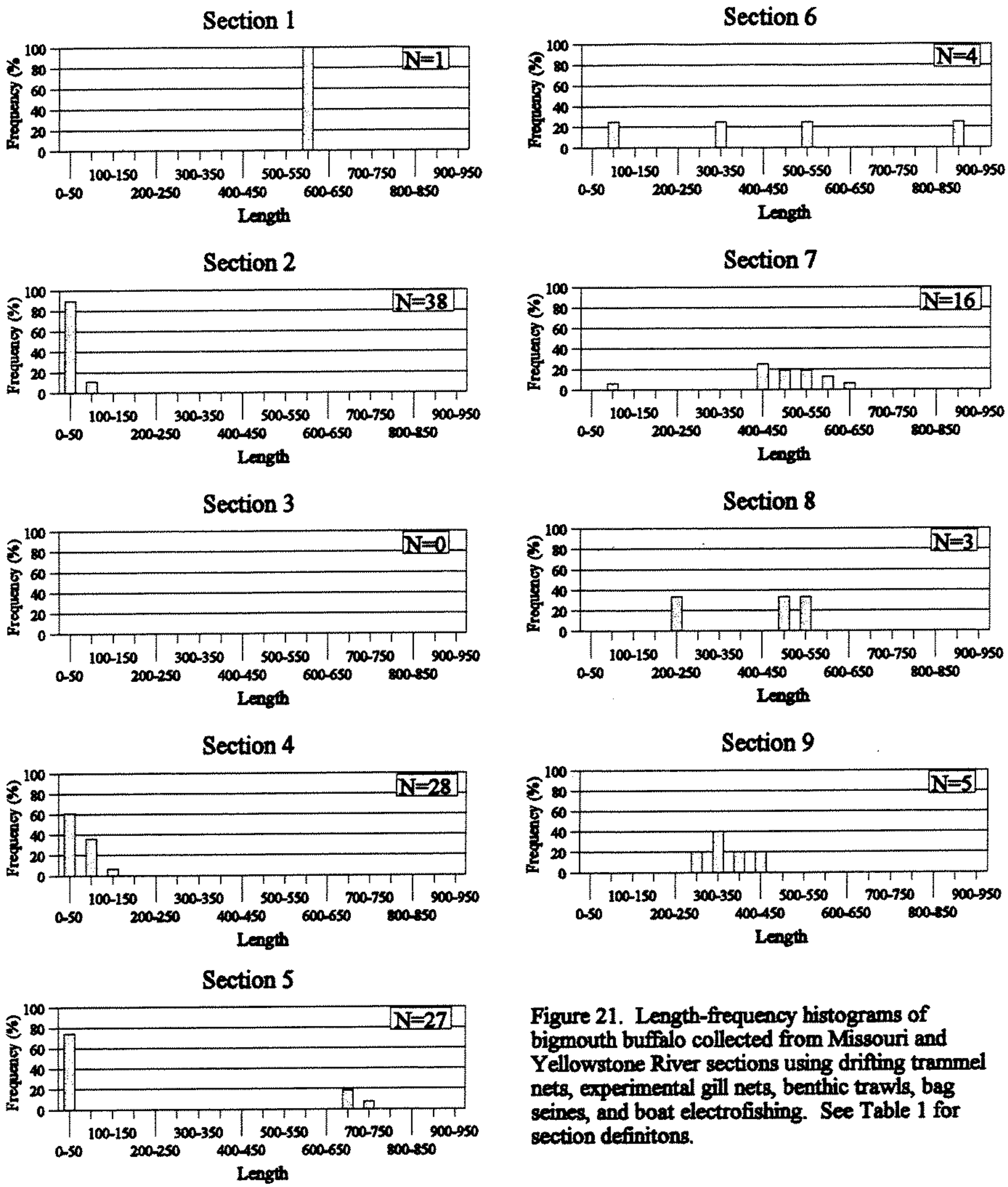


Figure 21. Length-frequency histograms of bigmouth buffalo collected from Missouri and Yellowstone River sections using drifting trammel nets, experimental gill nets, benthic trawls, bag seines, and boat electrofishing. See Table 1 for section definitons.

Bigmouth Buffalo

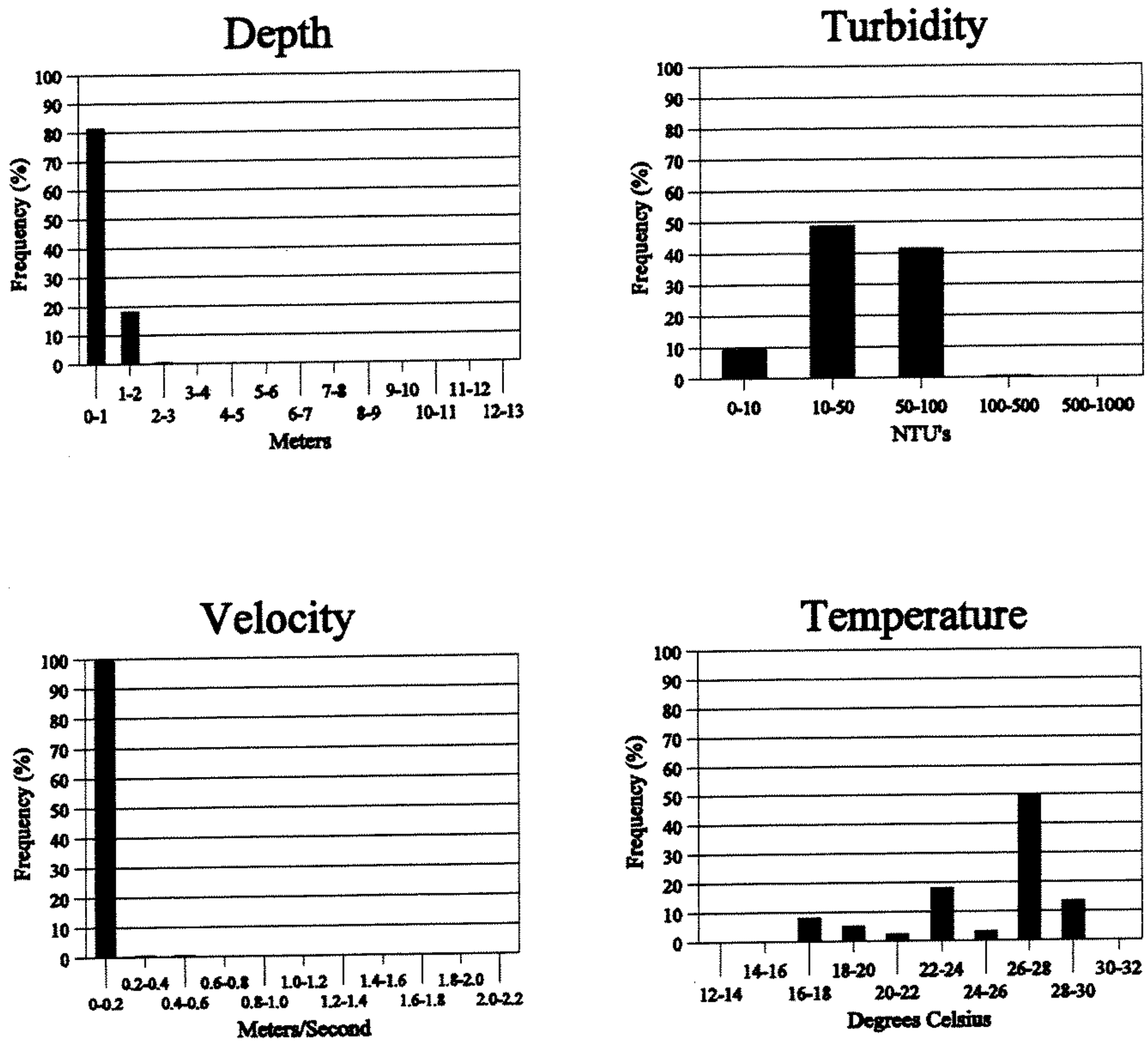


Figure 22. Frequency of occurrence of bigmouth buffalo (N=260) in various depth, velocity, turbidity, and water temperature intervals from Missouri and Yellowstone River collections.

Blue Catfish (BLCF)

A total of 86 blue catfish was collected; all fish were taken in channelized segments *22*, *23*, *25*, and *27*. Fish were captured in all six macrohabitat types. Most fish were captured in ISBs, SCCs, and TRMs with the benthic trawl (Figure 23). Blue catfish were captured with all gears except the bag seine. Blue catfish were captured with four different gears, stationary gill net, electrofishing boat, drifting trammel net, and benthic trawl in ISBs, but were only captured with the benthic trawl in CHXOs and TRMs, and only with the stationary gill net in SCNs (Table 12).

Most blue catfish were captured in shallow to moderate depths (83% in depths < 5 m) and low to moderate velocities (73% in velocities < 0.8 m/s) (Figure 25). Most fish were captured in turbid, warm water. Approximately 83% were captured in turbidities greater than 50 NTUs and 92% were captured in water warmer than 24°C. Warmer, turbid waters are characteristic of downstream segments, where all of the fish were captured.

All blue catfish were captured in sections 8 and 9, with most fish (80%) less than 150 mm in length (Figure 24). In section 8, 46% were 50-100 mm long. Section 8 also contained the largest fish (> 800 mm). Thirty-four fish were captured in section 9 with 44% between the lengths of 50 and 100 mm.

Blue Catfish

Table 12. Catch-Per-Unit-Effort (CPUE) for blue catfish by gear, across macrohabitats (CHXO=Channel Cross-Over, ISB=Inside Bend, OSB=Outside Bend, SCC=Secondary Channel Connected, SCN=Secondary Channel Non-Connected, and TRM=Tributary Mouth). Catch rates are reported as #fish/100m for benthic trawl (BT) and drifting trammel net (DTN), #fish/180 degree haul for a bag seine (BS), #fish/hr for a stationary gill net (SGN), and #fish/min for electrofishing (EF). Least-impacted segment numbers = standard font. Inter-reservoir segment numbers = bold font. Channelized segment numbers = italic font. A "-" indicates that no sample was taken.

Segment	CHXO		ISB					OSB			SCC				SCN			TRM			
	BT	DTN	BS	BT	DTN	EF	SGN	BT	DTN	EF	BS	BT	DTN	EF	BS	EF	SGN	BT	DTN	EF	SGN
3	-	0.00	-	-	0.00	0.00	-	-	0.00	0.00	-	-	0.00	0.00	-	-	0.00	-	-	-	-
5	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.00	-	-	-	-
7	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00	-	0.00	0.00	0.00	-	0.00	-	0.00	-	-	-	0.00
8	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00	-	0.00	0.00	0.00	-	0.00	-	-	-	-	-	-
9	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00	-	0.00	0.00	0.00	-	0.00	-	-	-	-	-	-
10	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	0.00	0.00	0.00	0.00	0.00	-
12	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00	0.00	0.00	-	-	-	0.00	0.00	0.00	-	-	0.00	0.00
14	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	0.00	0.00	-	-	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	-	-	-	-	-	-	-	0.00	0.00
19	0.00	0.00	-	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	0.00	-	-	-	-	0.00	0.00	0.00
22	0.00	0.00	-	0.12	0.00	0.00	0.01	0.00	0.00	0.00	-	-	-	-	0.00	0.00	0.00	0.93	0.00	0.01	0.00
23	0.00	0.00	0.00	0.77	0.04	0.00	0.02	0.00	0.00	0.01	0.00	0.40	0.00	0.01	-	-	-	0.00	0.00	0.00	0.00
25	0.08	0.00	0.00	0.40	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	-	0.00	0.00	0.00	0.00
27	0.07	0.00	0.00	0.13	0.04	0.01	0.00	0.20	0.00	0.03	0.00	0.20	0.00	0.04	0.00	0.00	0.02	-	-	0.00	0.00

Blue Catfish

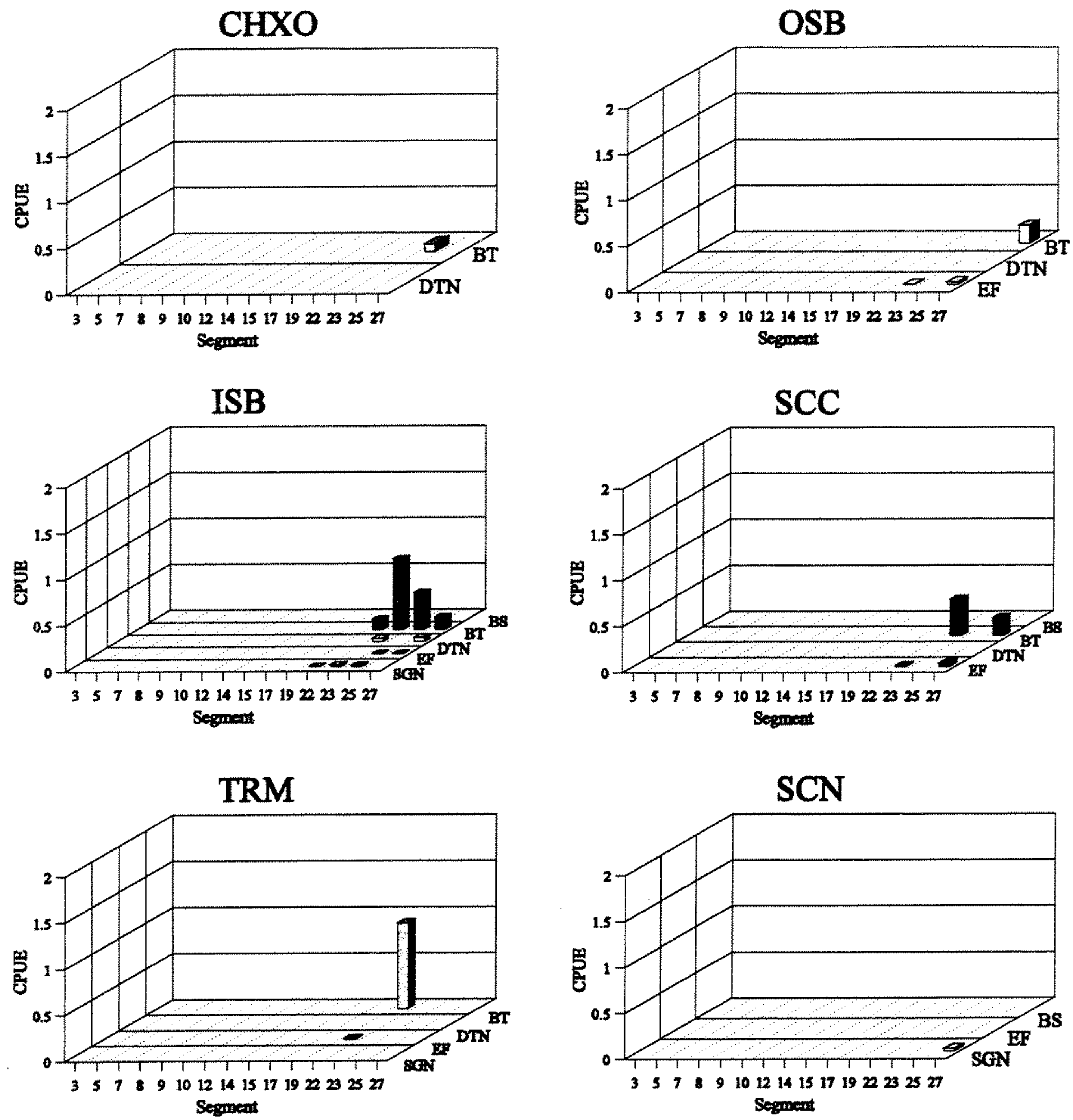
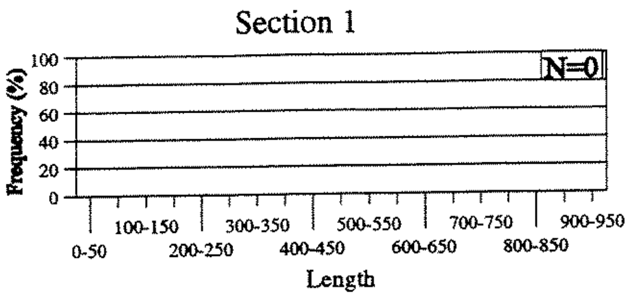
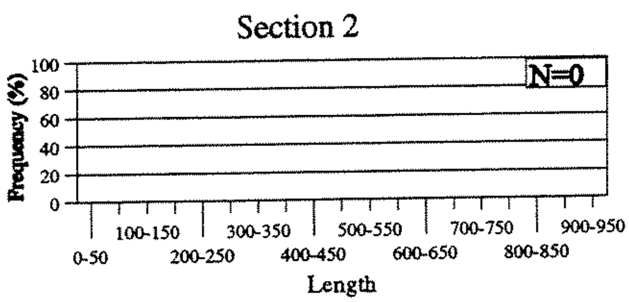
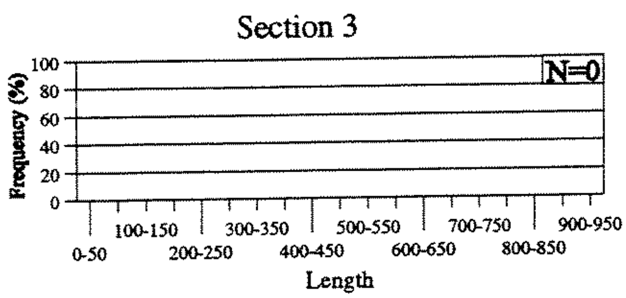


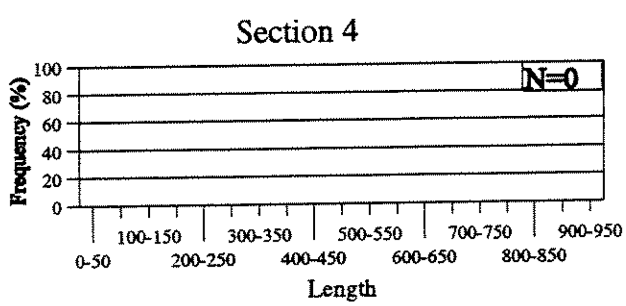
Figure 23. Trends of blue catfish catch rates among Missouri and Yellowstone River study segments and macrohabitats in 1997. Catch rates are reported as #fish/100m for benthic trawl (BT) and drifting trammel net (DTN), #fish/180 degree haul for a bag seine (BS), #fish/hr for a statinary gill net (SGN), and #fish/min for electrofishing (EF). See Appendix A for list of macrohabitat acronyms.

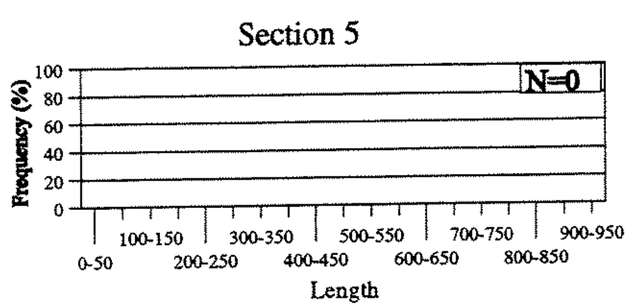
Blue Catfish

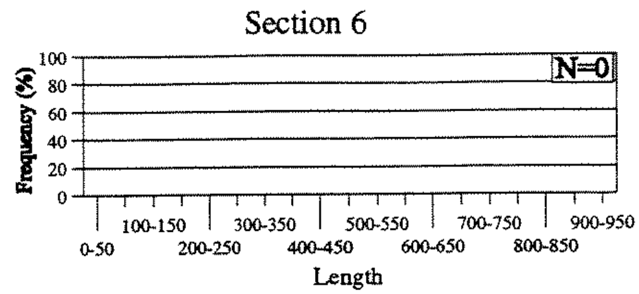


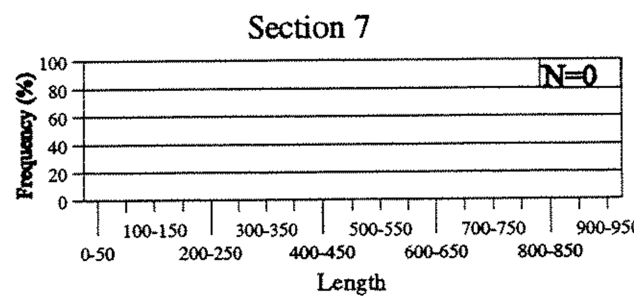


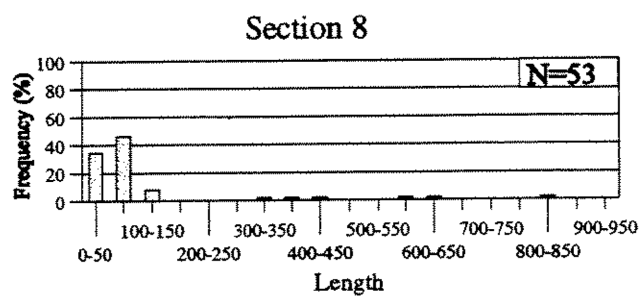












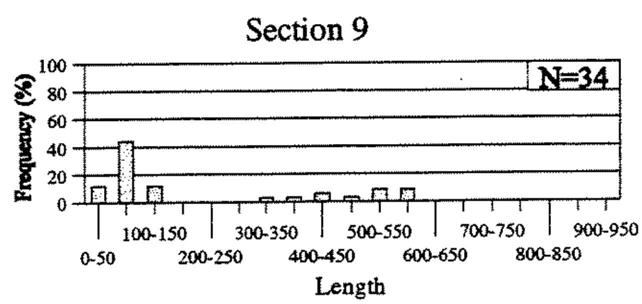


Figure 24. Length-frequency histograms of blue catfish collected from Missouri and Yellowstone River sections using drifting trammel nets, experimental gill nets, benthic trawls, bag seines, and boat electrofishing. See Table 1 for section definitons.

Blue Catfish

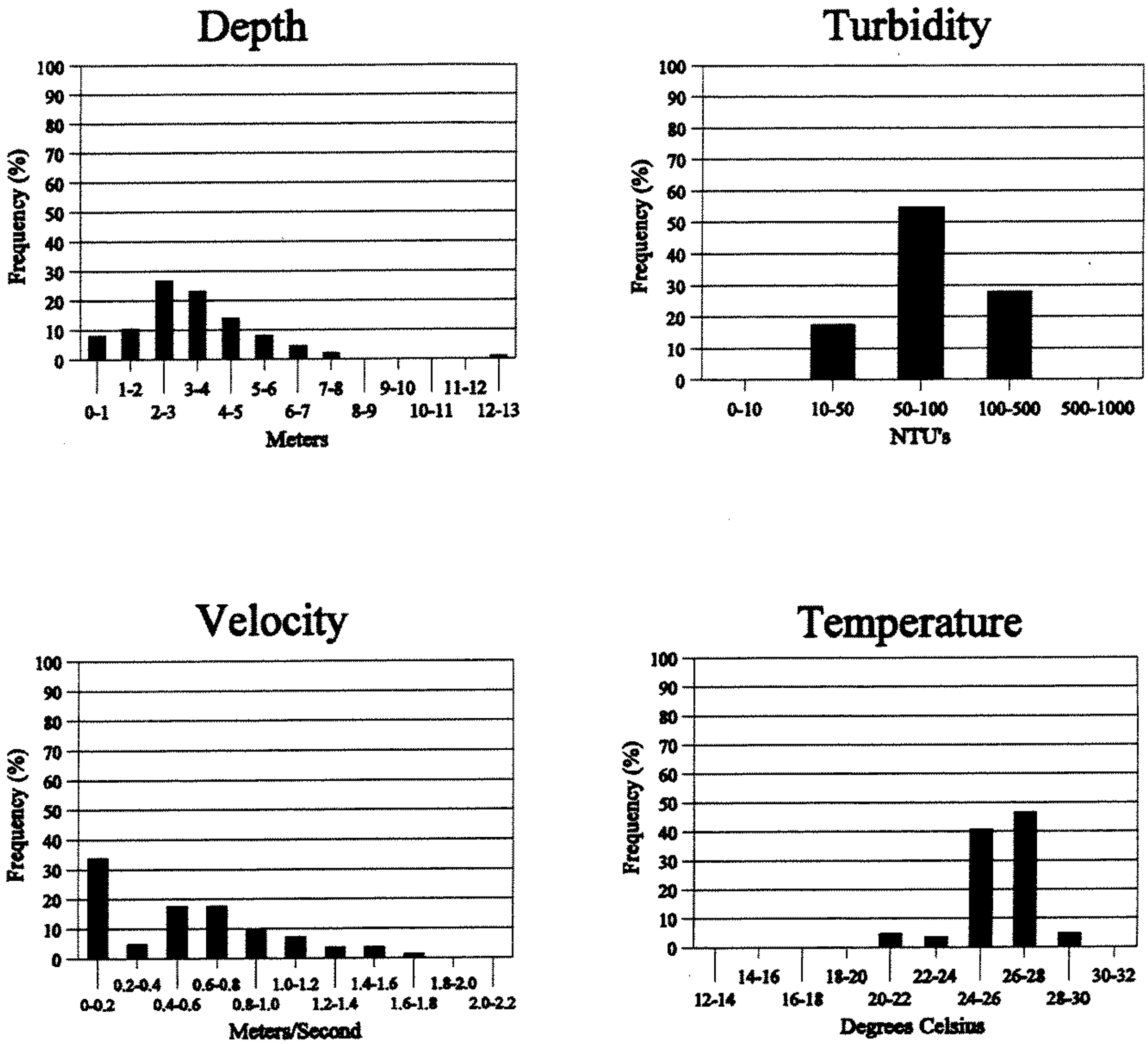


Figure 25. Frequency of occurrence of blue catfish (N=86) in various depth, velocity, turbidity, and water temperature intervals from Missouri and Yellowstone River collections.

Blue sucker (BUSK)

Blue suckers (n = 96) were captured throughout the river, with 80% captured in segments downstream from Gavins Point Dam (Table 9). The distribution of the 31 fish caught in 1996 was similar to that in 1997. Fish ranged in length from fingerlings to about 900 mm in length, but representation across all size classes was not found in any section, except perhaps in Section 8 along the Kansas border (Figure 27). Section 8 also had the widest length distribution of blue suckers in 1996. Only large fish were found in Sections 1, 3, 5, 7, and 9. Blue suckers were caught at a wide range of depths, turbidities, velocities and temperatures (Figure 28), but never in non-connected secondary channels. Catch rate was highest in the inside and outside bends of the main channel (Figure 26). Most fish were caught by drifting trammel nets (Table 13, Figure 26), but a few were collected by electrofishing and in gill nets in tributary mouths and inside bends. This information on blue suckers agrees with that presented in 1996 except that fish <200 mm were collected in 1997, whereas none in that size range were collected in 1996. The blue suckers (<200 mm) were captured below major tributaries like the Milk River in Montana and the Vermillion in South Dakota.

Blue Sucker

Table 13. Catch-Per-Unit-Effort (CPUE) for blue sucker by gear, across macrohabitats (CHXO=Channel Cross-Over, ISB=Inside Bend, OSB=Outside Bend, SCC=Secondary Channel Connected, SCN=Secondary Channel Non-Connected, and TRM=Tributary Mouth). Catch rates are reported as #fish/100m for benthic trawl (BT) and drifting trammel net (DTN), #fish/180 degree haul for a bag seine (BS), #fish/hr for a stationary gill net (SGN), and #fish/min for electrofishing (EF). Least-impacted segment numbers = standard font. Inter-reservoir segment numbers = bold font. Channelized segment numbers = italic font. A "-" indicates that no sample was taken.

Segment	CHXO		ISB					OSB			SCC				SCN			TRM			
	BT	DTN	BS	BT	DTN	EF	SGN	BT	DTN	EF	BS	BT	DTN	EF	BS	EF	SGN	BT	DTN	EF	SGN
3	-	0.00	-	-	0.00	0.00	-	-	0.00	0.02	-	-	0.00	0.00	-	-	0.00	-	-	-	-
5	0.00	0.00	-	0.00	0.03	0.00	-	0.00	0.03	0.00	-	0.00	0.04	0.00	-	0.00	0.00	-	-	-	-
7	0.00	0.00	0.00	0.00	0.00	-	-	0.03	0.00	-	0.00	0.00	0.00	-	0.00	-	0.00	-	-	-	0.00
8	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00	-	0.00	0.00	0.00	-	0.00	-	-	-	-	-	-
9	0.00	0.00	0.00	0.02	0.02	-	-	0.04	0.05	-	0.00	0.00	0.02	-	0.00	-	-	-	-	-	-
10	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	0.00	0.00	0.00	0.00	0.00	-
12	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00	0.00	0.00	-	-	-	0.00	0.00	0.00	-	-	0.00	0.03
14	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00
15	0.00	0.13	0.00	0.00	0.00	-	0.00	0.00	0.00	0.03	0.00	0.00	0.09	.003	-	0.00	0.00	-	-	0.00	0.01
17	0.00	0.00	0.00	0.00	0.45	0.03	0.06	0.00	0.00	0.03	-	-	-	-	-	-	-	-	-	0.00	0.00
19	0.00	0.00	-	-	-	0.00	0.02	0.00	0.00	0.03	0.00	0.00	-	0.00	-	-	-	-	0.00	0.00	0.00
22	0.00	0.00	-	0.00	0.25	0.01	0.00	0.00	0.00	0.03	-	-	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.14	0.05	0.00	0.00	0.00	0.01	0.00	0.00	0.17	0.00	-	-	-	0.00	0.00	0.00	0.00
25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00	-	-	-	0.00	0.00	0.00	0.00
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00

Blue Sucker

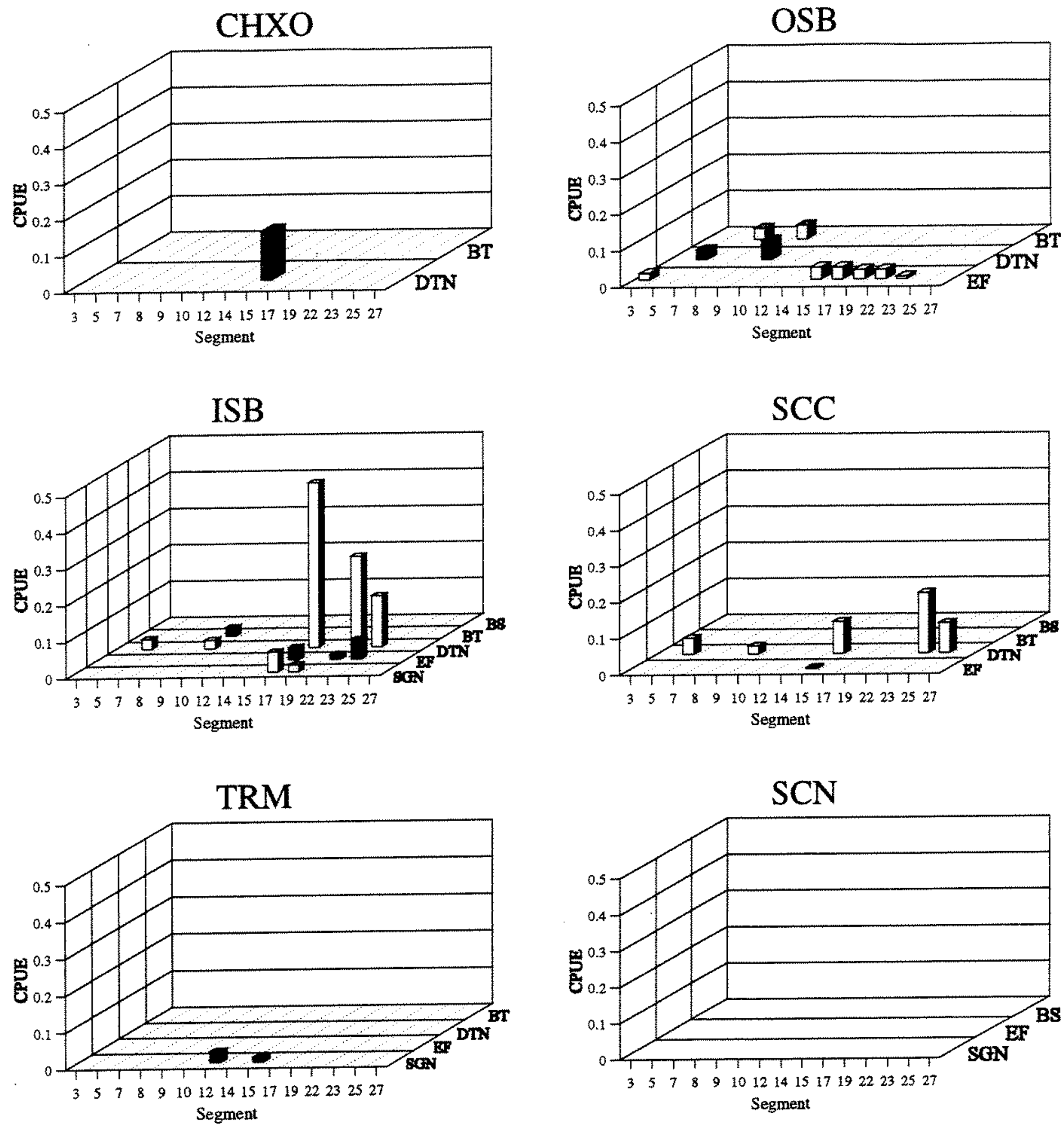
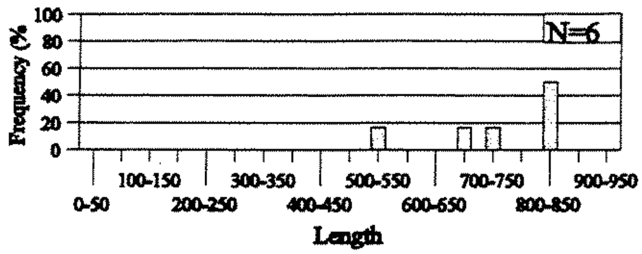


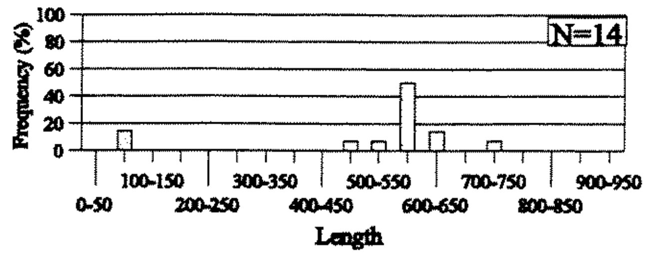
Figure 26. Trends of blue sucker catch rates among Missouri and Yellowstone River study segments and macrohabitats in 1997. Catch rates are reported as #fish/100m for benthic trawl (BT) and drifting trammel net (DTN), #fish/180 degree haul for a bag seine (BS), #fish/hr for a statinary gill net (SGN), and #fish/min for electrofishing (EF). See Appendix A for list of macrohabitat acronyms.

Blue Sucker

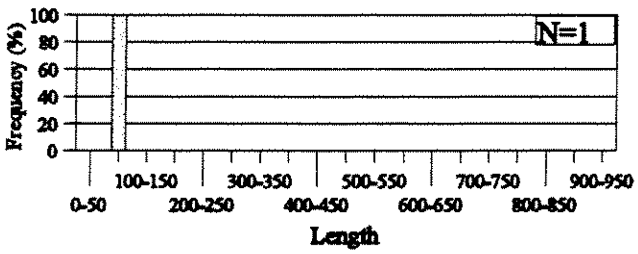
Section 1



Section 6



Section 2



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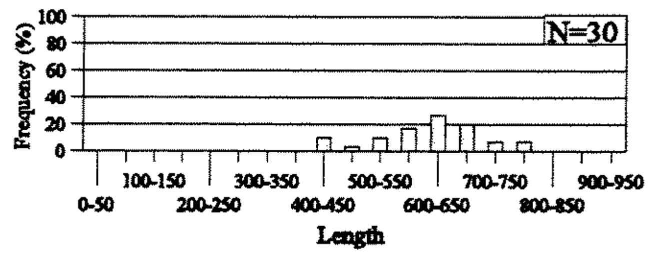
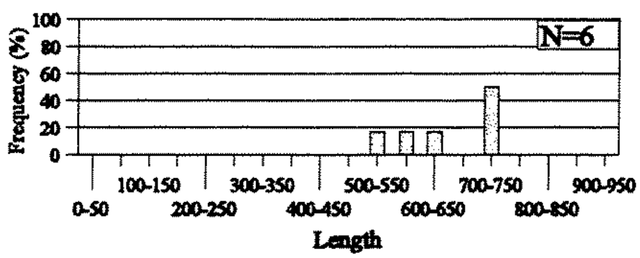
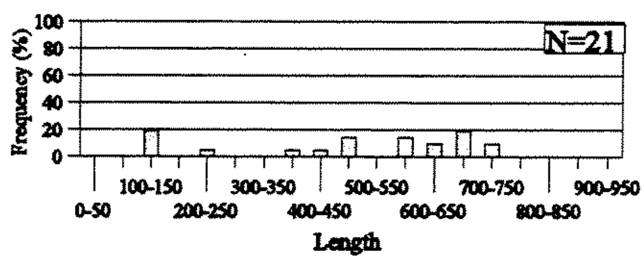


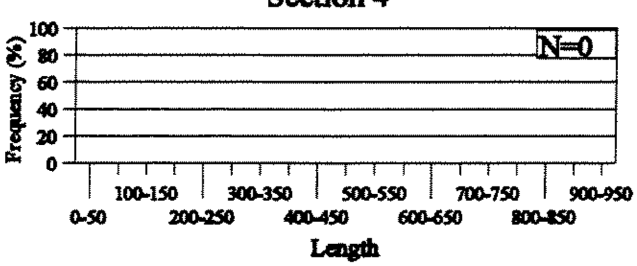
Section 3



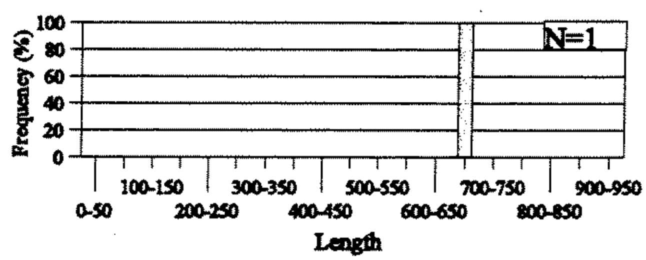
Section 8



Section 4



Section 9



Section 5

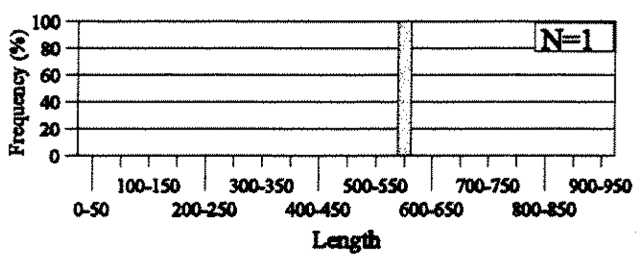


Figure 27. Length-frequency histograms of blue sucker collected from Missouri and Yellowstone River sections using drifting trammel nets, experimental gill nets, benthic trawls, bag seines, and boat electrofishing. See Table 1 for section definitons.

Blue Sucker

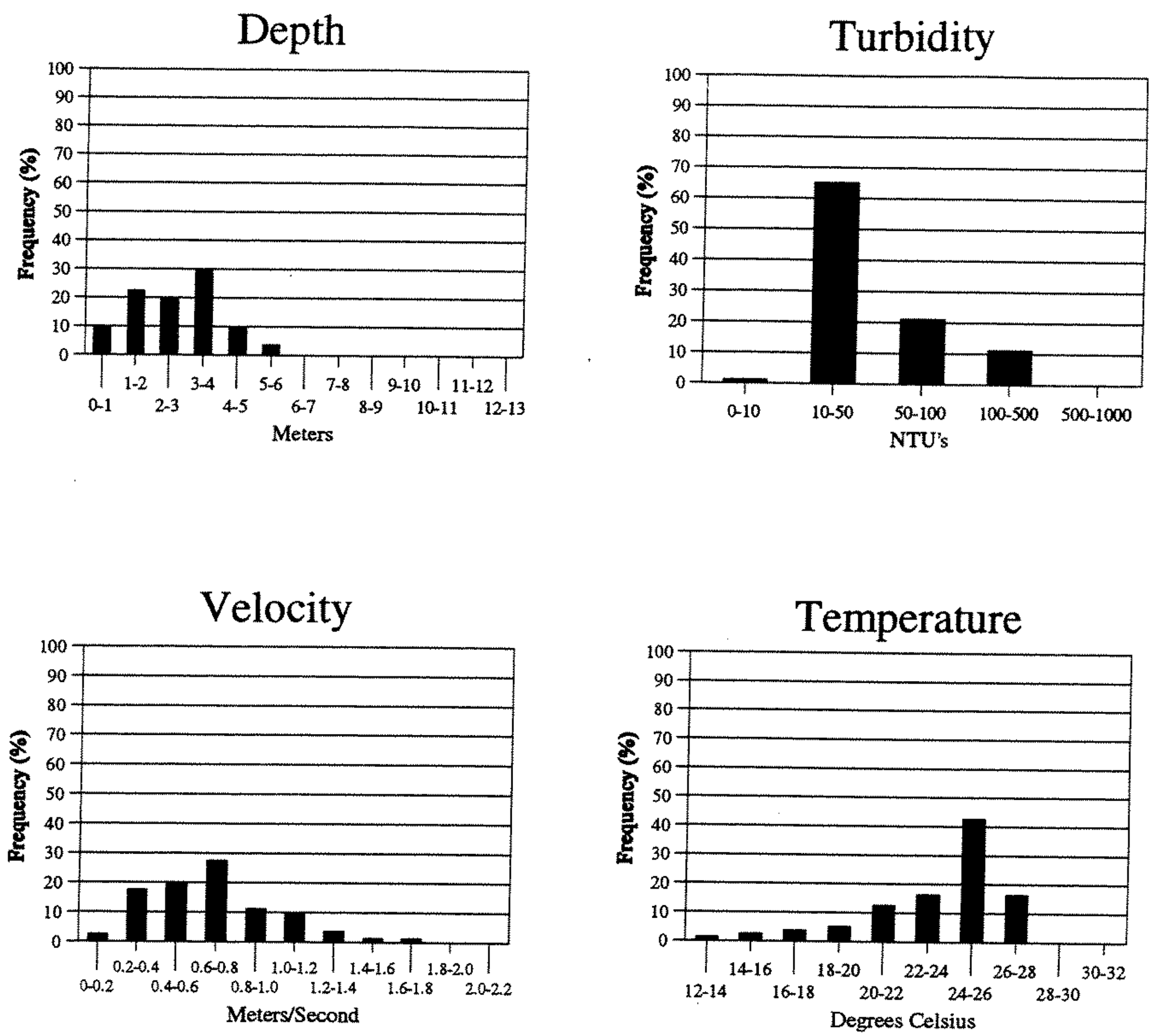


Figure 28. Frequency of occurrence of blue sucker (N=80) in various depth, velocity, turbidity, and water temperature intervals from Missouri and Yellowstone River collections.

Burbot (BRBT)

In 1997, 83 burbot were captured. Catches occurred in least impacted segments 3, 5, and 9 and in inter-reservoir segments **8**, **10**, and **15.** Fish were captured with all gears except the drifting trammel net (Figure 29; Table 14). Burbot were not collected downstream of segment **15** (rmi 753.0).

Most burbot were captured in shallow to intermediate depths (98% in depths < 4 m), low to intermediate velocities (95% in velocities < 0.8 m/s), low turbidities (76% between 10-50 NTUs), and cool waters (64% in temperatures < 16°C) (Figure 31). However, these fish were captured in a wide range of turbidities (10-1000 NTUs) and temperatures (14-26°C).

Most burbot (70%) were less than 150 mm in length with the widest distribution of lengths in section 1 (Figure 30). Burbot in section 1 ranged from 50-700 mm in length and 50-200 mm in length in section 4. Only burbot 50-100 mm long were captured in sections 2 and 3. No burbot were captured in sections 5, 7, 8, and 9.

Burbot

Table 14. Catch-Per-Unit-Effort (CPUE) for burbot by gear, across macrohabitats (CHXO=Channel Cross-Over, ISB=Inside Bend, OSB=Outside Bend, SCC=Secondary Channel Connected, SCN=Secondary Channel Non-Connected, and TRM=Tributary Mouth). Catch rates are reported as #fish/100m for benthic trawl (BT) and drifting trammel net (DTN), #fish/180 degree haul for a bag seine (BS), #fish/hr for a stationary gill net (SGN), and #fish/min for electrofishing (EF). Least-impacted segment numbers = standard font. Inter-reservoir segment numbers = bold font. Channelized segment numbers = italic font. A "-" indicates that no sample was taken.

Segment	CHXO		ISB					OSB			SCC				SCN			TRM			
	BT	DTN	BS	BT	DTN	EF	SGN	BT	DTN	EF	BS	BT	DTN	EF	BS	EF	SGN	BT	DTN	EF	SGN
3	-	0.00	-	-	0.00	0.00	-	-	0.00	0.02	-	-	0.00	0.00	-	-	0.00	-	-	-	-
5	0.00	0.00	-	0.00	0.00	0.10	-	0.06	0.00	0.02	-	0.00	0.00	0.53	-	0.00	0.00	-	-	-	-
7	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00	-	0.00	0.00	0.00	-	0.00	-	0.00	-	-	-	0.00
8	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00	-	0.00	0.03	0.00	-	0.00	-	-	-	-	-	-
9	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00	-	0.06	0.00	0.00	-	0.00	-	-	-	-	-	-
10	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00	0.08	0.00	0.00	0.00	0.05	-	0.00	0.00	0.00	0.00	0.00	-
12	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00	0.00	0.00	-	-	-	0.00	0.00	0.00	-	-	0.00	0.00
14	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	-	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	-	0.00	0.00	-	-	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	-	-	-	-	-	-	-	0.00	0.00
19	0.00	0.00	-	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	0.00	-	-	-	-	0.00	0.00	0.00
22	0.00	0.00	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	-	0.00	0.00	0.00	0.00
25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	-	0.00	0.00	0.00	0.00
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00

Burbot

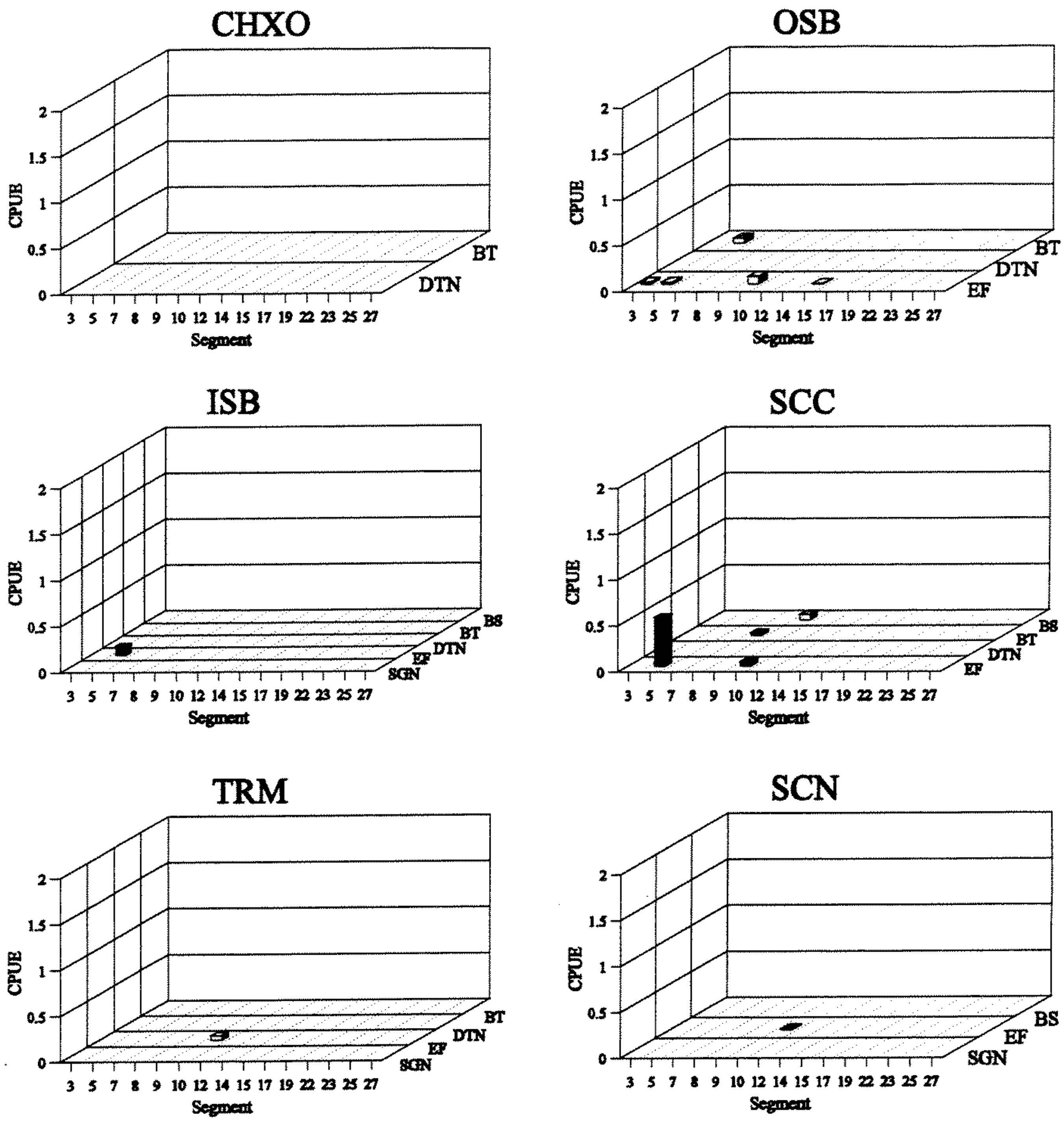
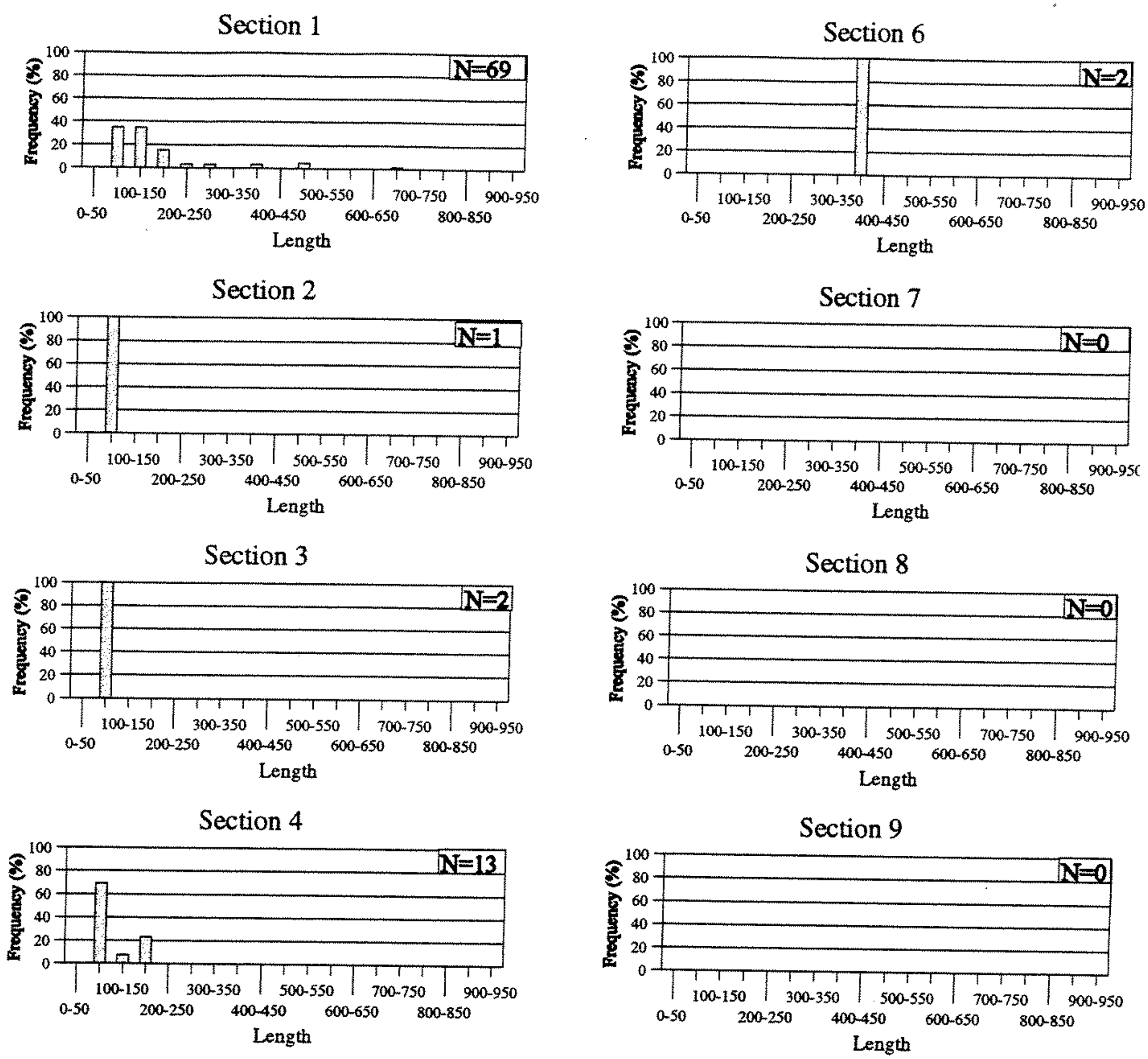


Figure 29. Trends of burbot catch rates among Missouri and Yellowstone River study segments and macrohabitats in 1997. Catch rates are reported as #fish/100m for benthic trawl (BT) and drifting trammel net (DTN), #fish/180 degree haul for a bag seine (BS), #fish/hr for a statinary gill net (SGN), and #fish/min for electrofishing (EF). See Appendix A for list of macrohabitat acronyms.

Burbot



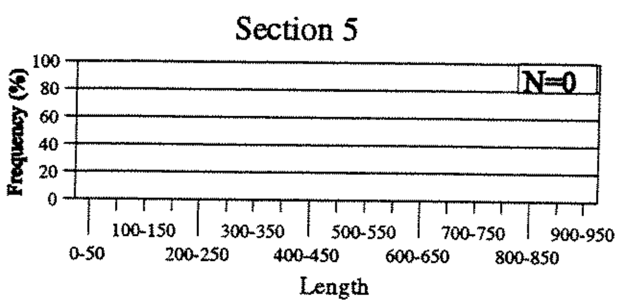


Figure 30. Length-frequency histograms of burbot collected from Missouri and Yellowstone River sections using drifting trammel nets, experimental gill nets, benthic trawls, bag seines, and boat electrofishing. See Table 1 for section definitons.

Burbot

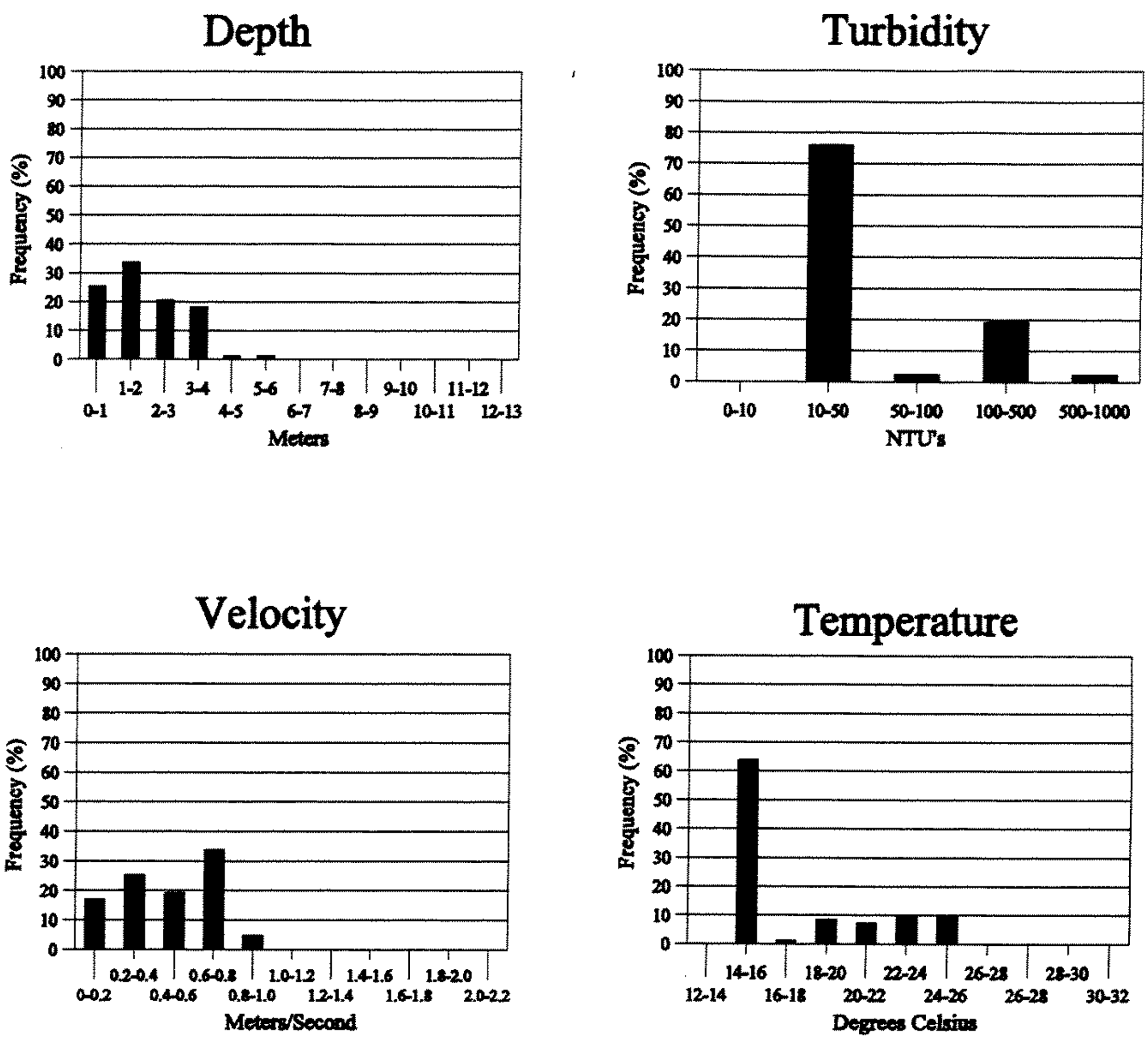


Figure 31. Frequency of occurrence of burbot (N=83) in various depth, velocity, turbidity, and water temperature intervals from Missouri and Yellowstone River collections.

Channel Catfish (CNCF)

A total of 1,724 channel catfish was captured in all segments and all macrohabitats in 1997. Catfish were most commonly captured in channelized segments in ISBs and SCCs with the bag seine and the benthic trawl, however, they were commonly captured in other segments as well (Figure 32). Highest catch rates were obtained with the bag seine in ISB in segments *17* (3.57/haul) and *27* (4.67/haul) and the benthic trawl in SCC in segments *23* (3.95/100 m) and *27* (5.81/100 m) (Table 15).

Most channel catfish were captured in shallow to moderate depths (86% in depths < 4 m), slow to moderate velocities (79% in velocities < 0.6m/s), intermediate turbidities (57% between 50-500 NTUs), and warm waters (71% in temperatures > 22°C) (Figure 34). Less than 5% of all catfish were captured in depths greater than 7 m, turbidities less than 10 NTUs, velocities greater than 1.4 m/s, and temperatures less than 16°C.

In most sections, catfish were < 300 mm in length (Figure 33). Sections 1, 3, 6, 7, 8, and 9 had high proportions of channel catfish < 100 mm, indicating successful reproduction in these segments. Catches in sections 2 and 5 contained few fish < 350 mm in length.

Channel Catfish

Table 15. Catch-Per-Unit-Effort (CPUE) for channel catfish by gear, across macrohabitats (CHXO=Channel Cross-Over, ISB=Inside Bend, OSB=Outside Bend, SCC=Secondary Channel Connected, SCN=Secondary Channel Non-Connected, and TRM=Tributary Mouth). Catch rates are reported as #fish/100m for benthic trawl (BT) and drifting trammel net (DTN), #fish/180 degree haul for a bag seine (BS), #fish/hr for a stationary gill net (SGN), and #fish/min for electrofishing (EF). Least-impacted segment numbers = standard font. Inter-reservoir segment numbers = bold font. Channelized segment numbers = italic font. A "-" indicates that no sample was taken.

Segment	CHXO		ISB					OSB			SCC				SCN			TRM			
	BT	DTN	BS	BT	DTN	EF	SGN	BT	DTN	EF	BS	BT	DTN	EF	BS	EF	SGN	BT	DTN	EF	SGN
3	-	0.02	-	-	0.00	0.40	-	-	0.00	0.06	-	-	0.22	0.05	-	-	0.12	-	-	-	-
5	1.35	0.00	-	0.39	0.00	0.05	-	2.25	0.03	0.05	-	0.16	0.00	0.03	-	0.00	0.49	-	-	-	-
7	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00	-	0.00	0.02	0.00	-	0.00	-	0.00	-	-	-	0.00
8	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00	-	0.00	0.11	0.00	-	0.00	-	-	-	-	-	-
9	0.07	0.02	1.53	0.26	0.42	-	-	0.14	0.12	-	1.03	0.11	0.00	-	1.94	-	-	-	-	-	-
10	0.09	0.00	1.00	0.15	0.00	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	0.01	0.00	0.67	0.00	0.00	-
12	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00	0.00	0.00	-	-	-	0.00	0.00	0.00	-	-	0.00	0.00
14	0.00	0.04	-	0.00	0.00	0.00	-	0.00	0.04	0.01	0.00	0.02	0.40	0.04	0.00	0.00	0.57	-	-	0.02	0.28
15	0.00	0.47	0.27	0.00	0.02	-	0.05	0.00	0.00	0.13	0.89	0.00	0.04	0.03	-	0.03	0.12	-	-	0.38	0.04
17	0.07	0.00	3.57	0.23	0.11	0.00	0.05	0.00	0.00	0.00	-	-	-	-	-	-	-	-	-	0.00	0.10
19	0.07	0.00	-	-	-	0.00	0.01	0.00	0.00	0.01	1.50	0.83	-	0.00	-	-	-	-	0.00	0.03	0.24
22	0.04	0.00	-	2.01	0.04	0.14	0.00	0.00	0.00	0.53	-	-	-	-	3.50	0.12	0.06	1.72	0.00	0.21	0.01
23	0.04	0.00	2.00	1.98	0.16	0.37	0.00	0.04	0.00	1.01	0.75	3.95	0.00	0.29	-	-	-	0.00	0.00	0.14	0.17
25	0.56	0.00	2.13	2.73	0.00	0.09	0.00	0.19	0.00	0.05	0.54	1.68	0.00	0.08	-	-	-	0.00	0.00	0.11	0.11
27	0.00	0.00	4.67	2.36	0.00	0.12	0.01	0.13	0.00	0.11	1.50	5.81	0.00	0.13	1.33	0.18	0.08	-	-	0.11	0.11

Channel Catfish

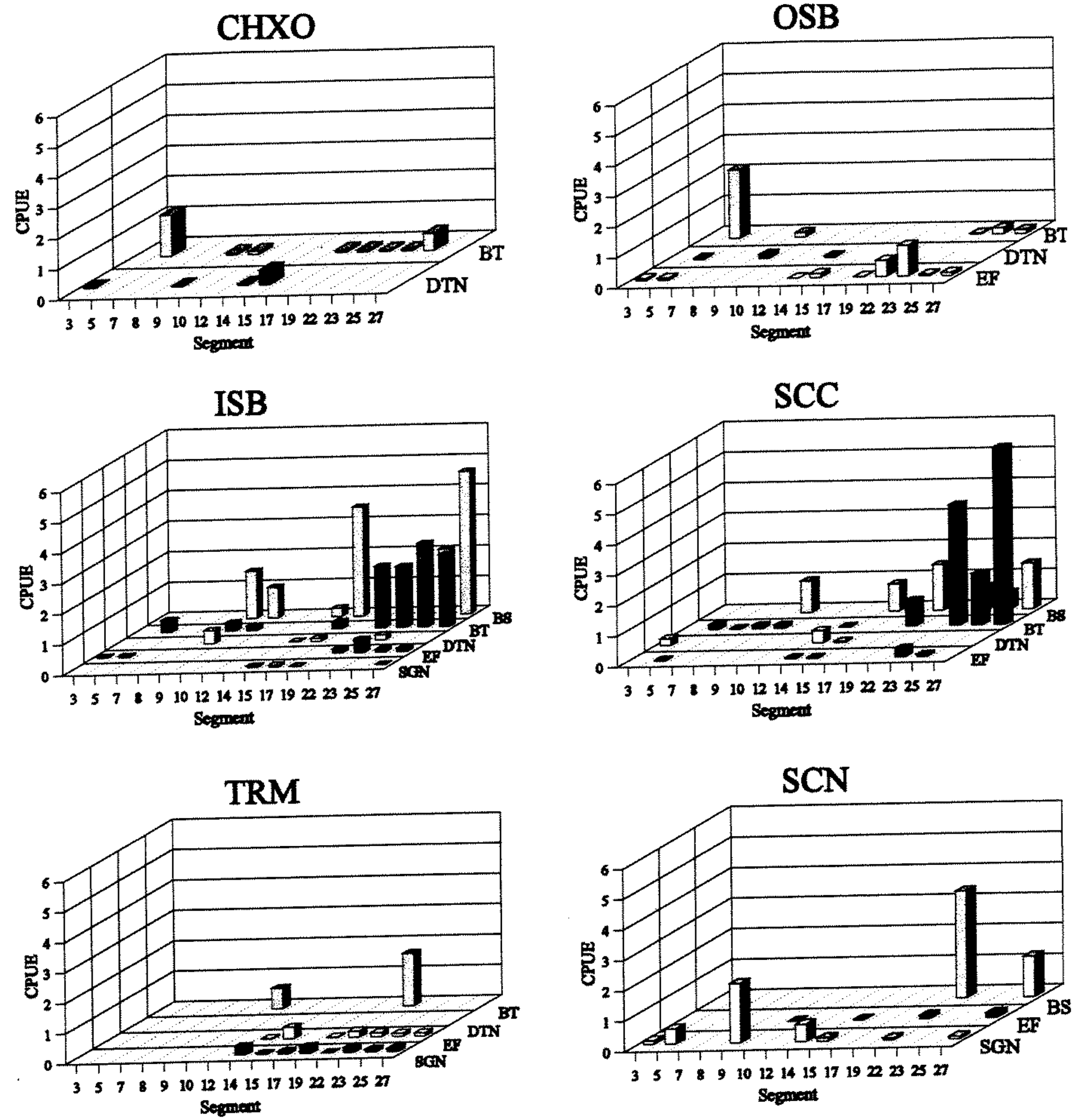
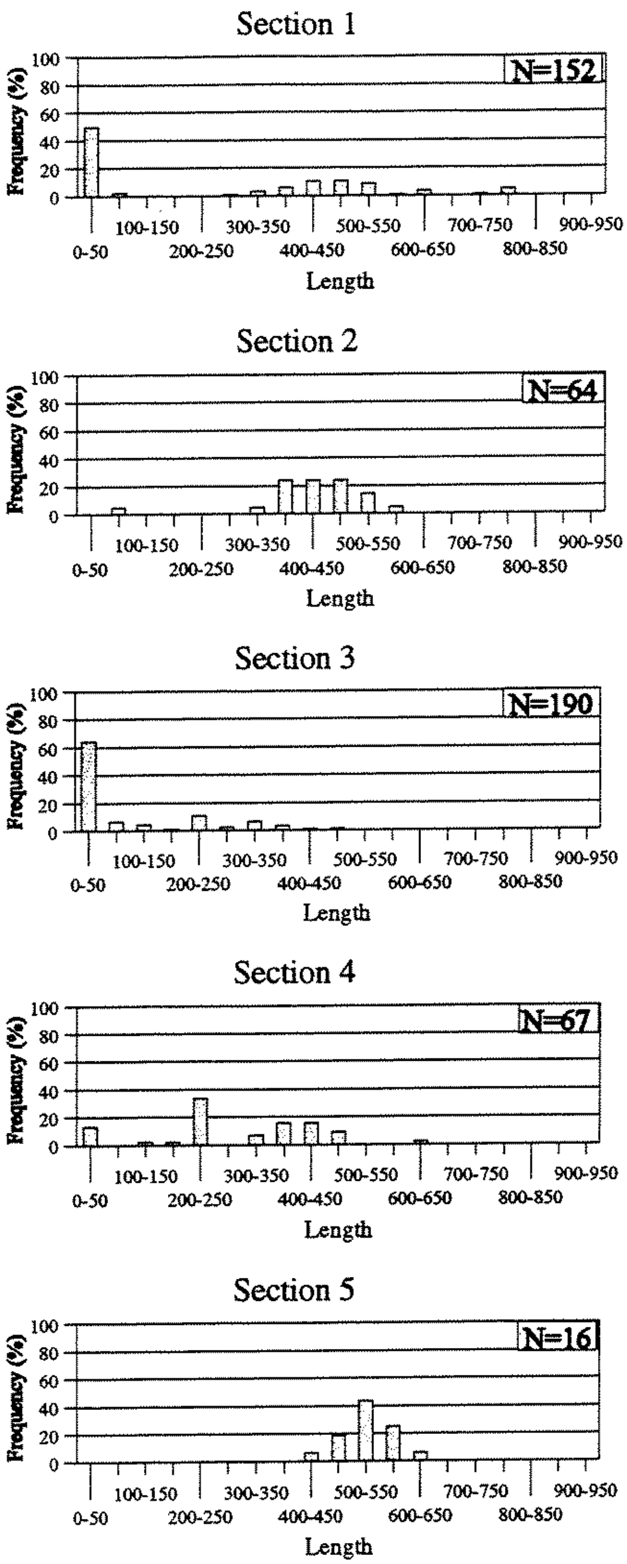


Figure 32. Trends of channel catfish catch rates among Missouri and Yellowstone River study segments and macrohabitats in 1997. Catch rates are reported as #fish/100m for benthic trawl (BT) and drifting trammel net (DTN), #fish/180 degree haul for a bag seine (BS), #fish/hr for a statinary gill net (SGN), and #fish/min for electrofishing (EF). See Appendix A for list of macrohabitat acronyms.

Channel Catfish



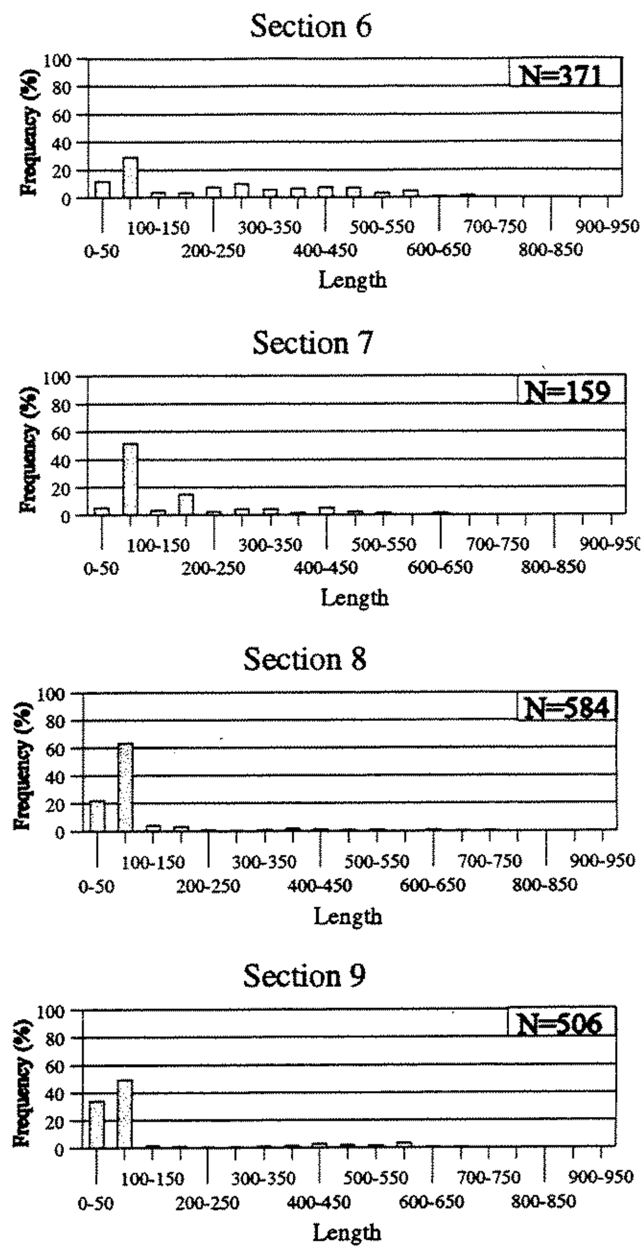


Figure 33. Length-frequency histograms of channel catfish collected from Missouri and Yellowstone River sections using drifting trammel nets, experimental gill nets, benthic trawls, bag seines, and boat electrofishing. See Table 1 for section definitons.

Channel Catfish

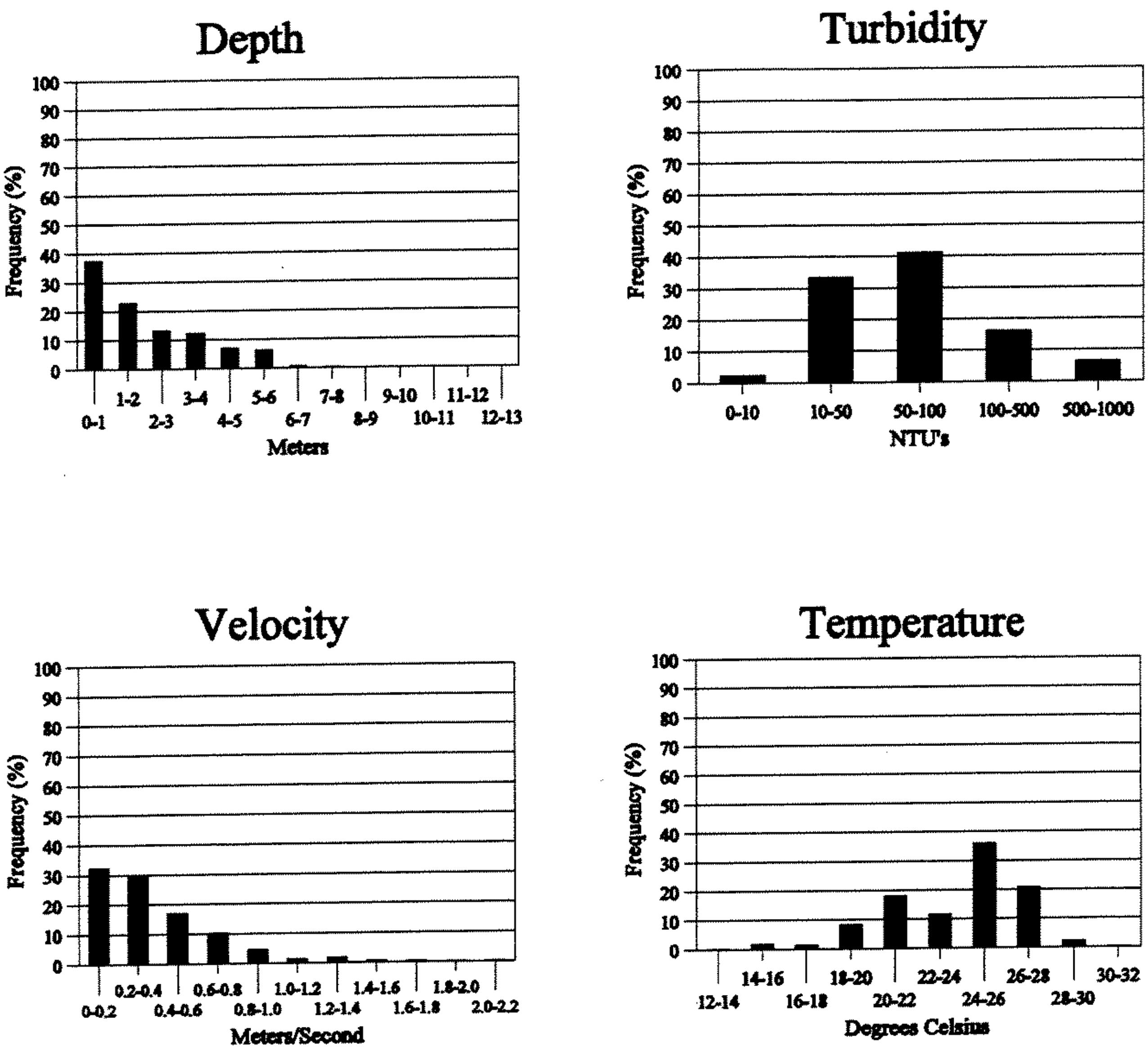


Figure 34. Frequency of occurrence of channel catfish (N=1724) in various depth, velocity, turbidity, and water temperature intervals from Missouri and Yellowstone River collections.

Common carp (CARP)

Common carp (n = 1,235) were captured in all segments in a roughly uniform distribution throughout the river (Table 9), whereas in 1996, the population abundance seemed to be higher in the lower-river sections. Fish ranged from fingerlings to about 750 mm in length, with a high proportion in the 400 – 600 mm length category. However a variety of length classes were found in most sections of the river (Figure 36). Recruitment of young fish was found in all Sections except Section 5, the inter-reservoir section between Garrison Dam and Lake Oahe. Common carp were caught in all habitat types (Figure 35), and usually at shallow depths, and where water velocity was low and water temperature was 20 – 30 C (Figure 37). Most fish were caught by electrofishing (Table 16, Figure 35). Electrofishing CPUE was usually between 0.1 and 0.4 fish/min (Table 16). This information on common carp from the 1997 sampling effort agrees closely with that presented in 1996.

Common Carp

Table 16. Catch-Per-Unit-Effort (CPUE) for common carp by gear, across macrohabitats (CHXO=Channel Cross-Over, ISB=Inside Bend, OSB=Outside Bend, SCC=Secondary Channel Connected, SCN=Secondary Channel Non-Connected, and TRM=Tributary Mouth). Catch rates are reported as #fish/100m for benthic trawl (BT) and drifting trammel net (DTN), #fish/180 degree haul for a bag seine (BS), #fish/hr for a stationary gill net (SGN), and #fish/min for electrofishing (EF). Least-impacted segment numbers = standard font. Inter-reservoir segment numbers = bold font. Channelized segment numbers = italic font. A "-" indicates that no sample was taken.

Segment	CHXO		ISB					OSB			SCC				SCN			TRM			
	BT	DTN	BS	BT	DTN	EF	SGN	BT	DTN	EF	BS	BT	DTN	EF	BS	EF	SGN	BT	DTN	EF	SGN
3	-	0.02	-	-	0.00	0.33	-	-	0.00	0.25	-	-	0.44	0.45	-	-	0.00	-	-	-	-
5	0.00	0.00	-	0.00	0.03	0.12	-	0.00	0.11	0.19	-	0.00	0.00	0.06	-	0.00	0.09	-	-	-	-
7	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00	-	0.06	0.00	0.00	-	0.00	-	0.00	-	-	-	0.00
8	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00	-	0.00	0.00	0.00	-	22.7	-	-	-	-	-	-
9	0.00	0.00	0.00	0.00	0.05	-	-	0.00	0.00	-	0.03	0.00	0.02	-	0.06	-	-	-	-	-	-
10	0.00	0.04	0.00	0.00	0.00	-	-	0.00	0.00	0.01	0.00	0.00	0.00	0.10	-	0.16	0.00	0.00	0.00	0.00	-
12	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00	0.07	0.00	-	-	-	0.00	0.45	0.00	-	-	0.32	0.00
14	0.00	0.00	-	0.00	0.00	0.22	-	0.00	0.00	0.12	0.00	0.00	0.09	0.27	0.00	0.25	0.14	-	-	0.34	0.14
15	0.00	0.00	0.00	0.00	0.00	-	0.00	0.00	0.00	0.31	0.06	0.00	0.00	0.12	-	0.20	0.09	-	-	0.44	0.03
17	0.00	0.00	0.00	0.00	0.00	0.07	0.01	0.00	0.00	0.01	-	-	-	-	-	-	-	-	-	0.08	0.02
19	0.00	0.00	-	-	-	0.04	0.00	0.00	0.00	0.10	1.00	0.00	-	0.06	-	-	-	-	0.00	0.20	0.06
22	0.00	0.00	-	0.00	0.00	0.19	0.01	0.00	0.00	0.11	-	-	-	-	0.00	0.25	0.04	0.13	0.13	0.26	0.02
23	0.00	0.00	0.00	0.00	0.00	0.14	0.01	0.00	0.00	0.10	0.00	0.00	0.00	0.26	-	-	-	0.00	0.20	0.27	0.09
25	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.12	-	-	-	0.22	0.00	0.49	0.09
27	0.00	0.00	0.00	0.04	0.00	0.19	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.11	0.07	0.11	0.06	-	-	0.37	0.08

Common Carp

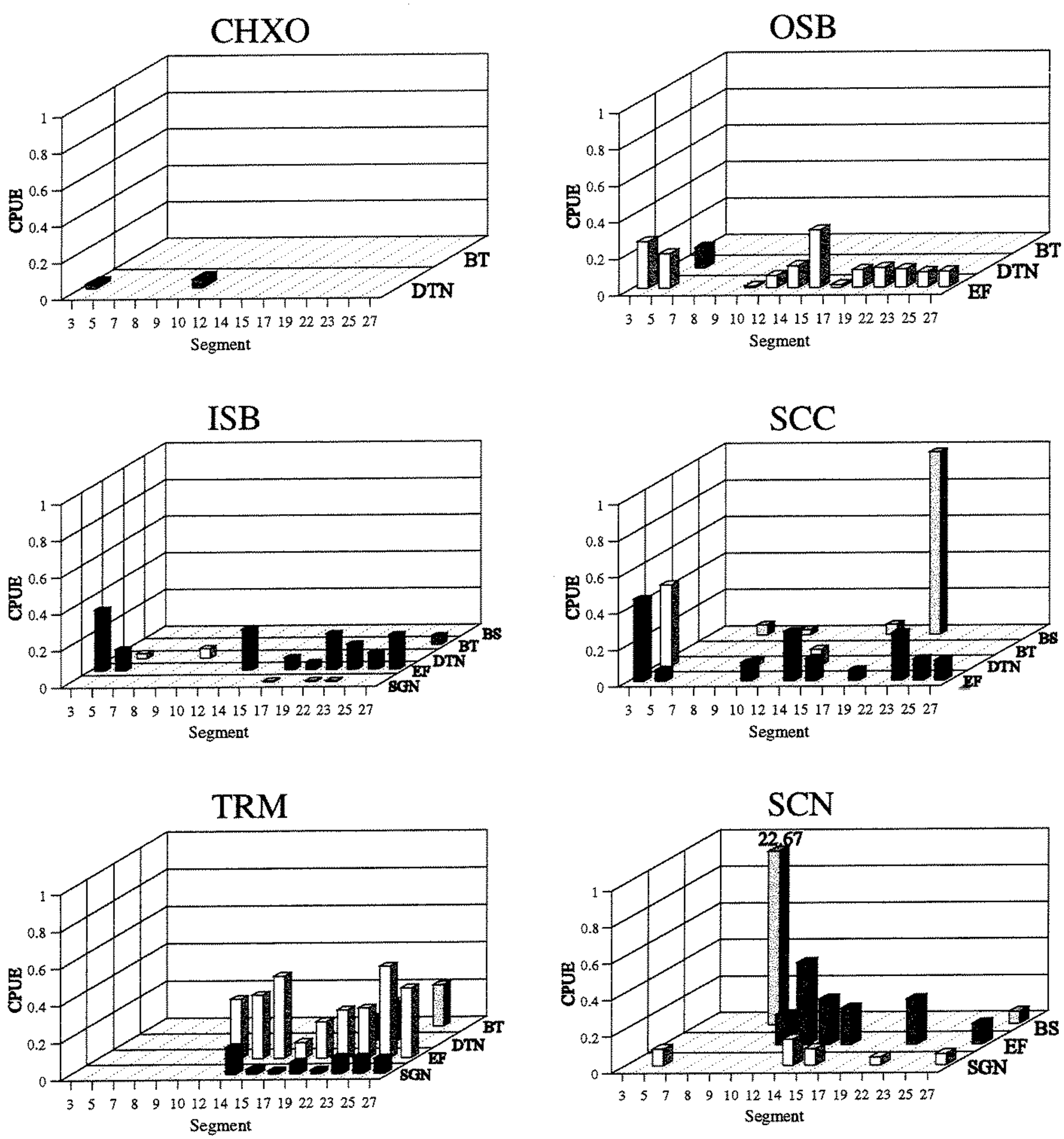
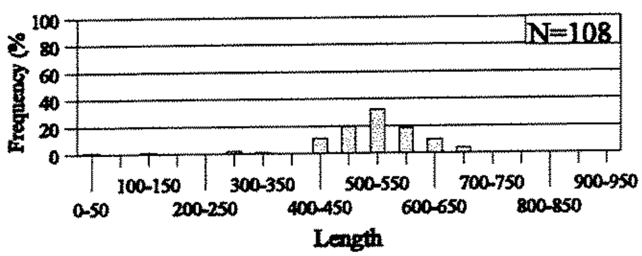


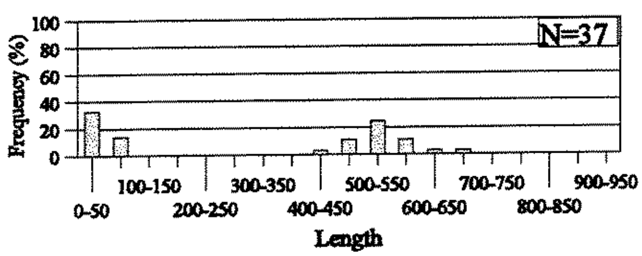
Figure 35. Trends of common carp catch rates among Missouri and Yellowstone River study segments and macrohabitats in 1997. Catch rates are reported as #fish/100m for benthic trawl (BT) and drifting trammel net (DTN), #fish/180 degree haul for a bag seine (BS), #fish/hr for a statinary gill net (SGN), and #fish/min for electrofishing (EF). See Appendix A for list of macrohabitat acronyms.

Common Carp

Section 1



Section 2



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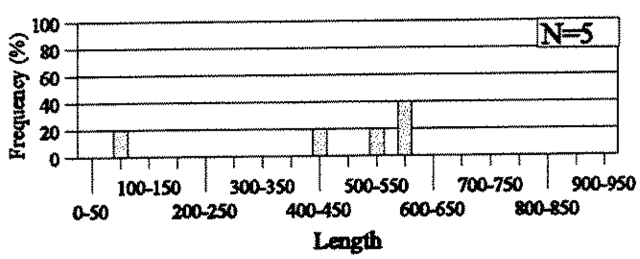

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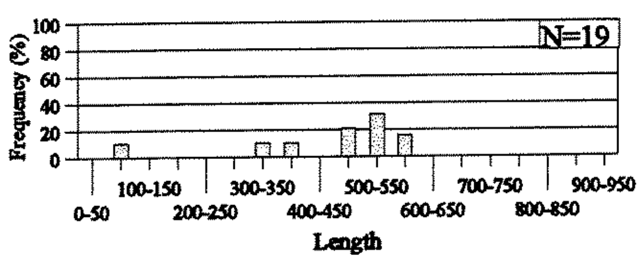

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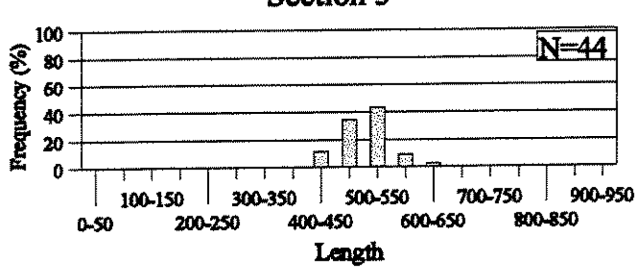

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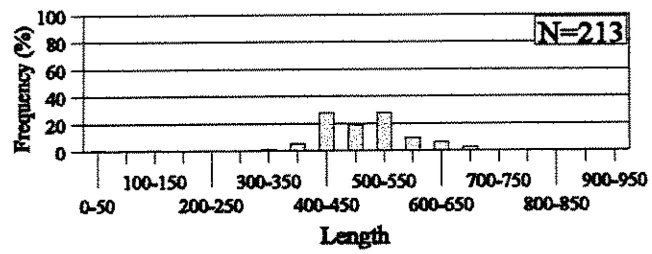

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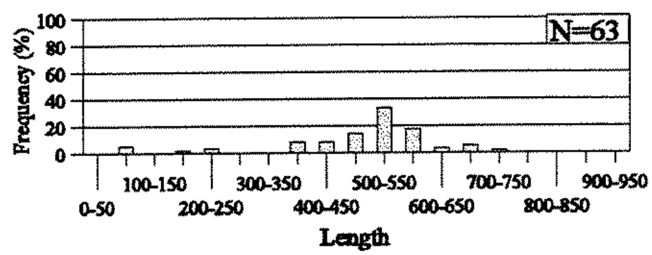

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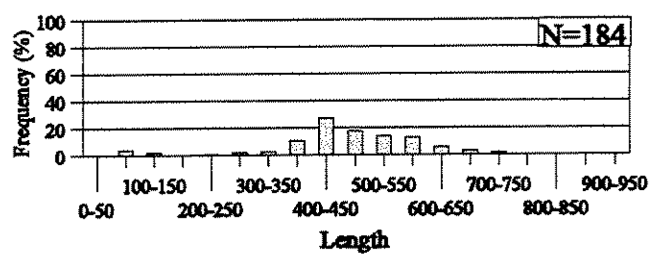


Section 9

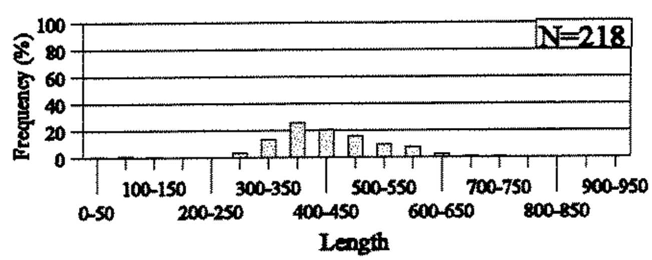


Figure 36. Length-frequency histograms of common carp collected from Missouri and Yellowstone River sections using drifting trammel nets, experimental gill nets, benthic trawls, bag seines, and boat electrofishing. See Table 1 for section definitons.

Common Carp

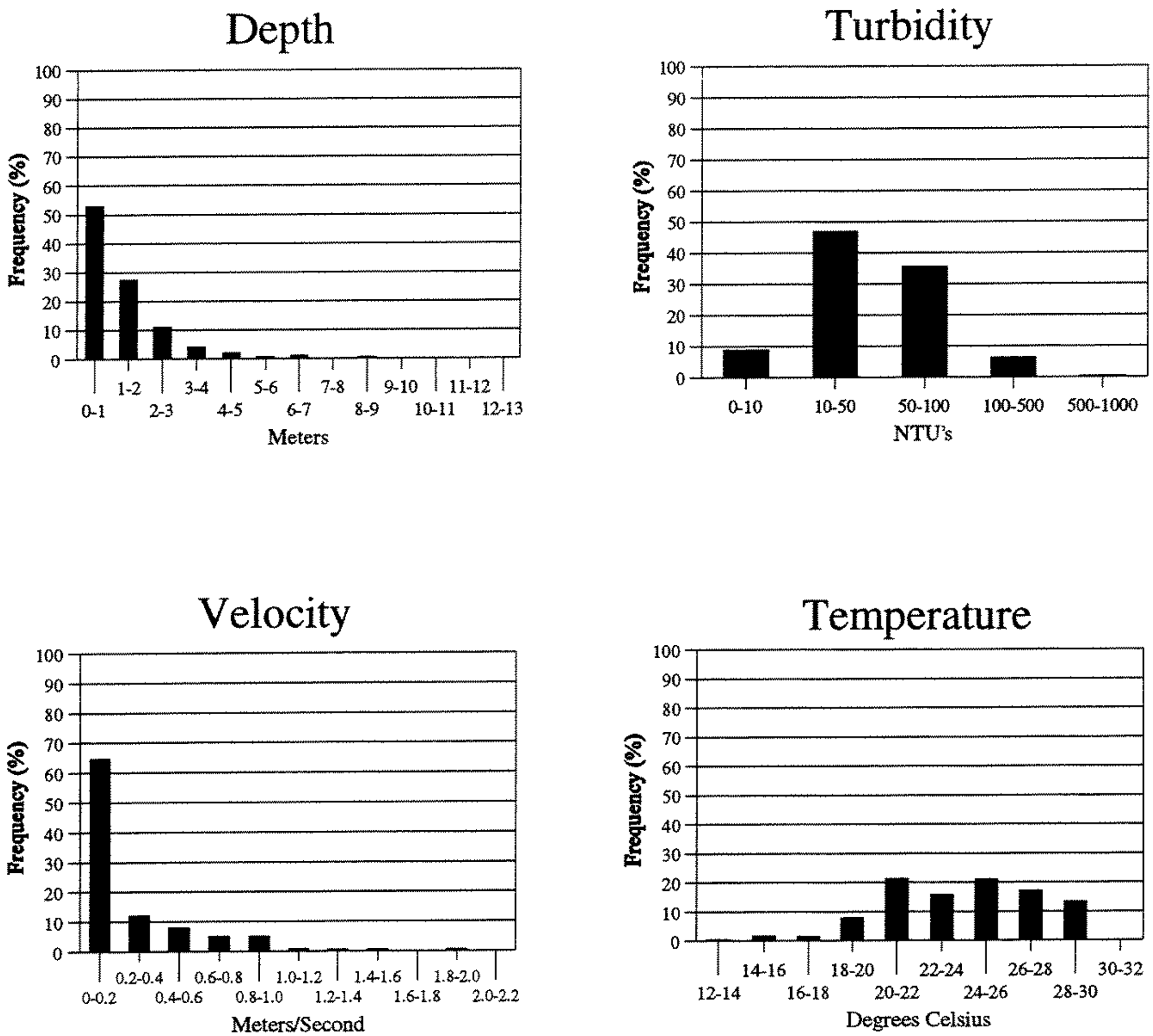


Figure 37. Frequency of occurrence of common carp (N=1080) in various depth, velocity, turbidity, and water temperature intervals from Missouri and Yellowstone River collections.

Emerald shiner (ERSN)

Emerald shiners (n = 6,891) were rare or absent only from inter-reservoir segments 7, 8 and 12 (Table 9), which confirmed the general distribution pattern found in 1996. Two size classes of this small minnow were found in most Sections (Figure 39). Emerald shiners were usually caught where depths were <4 m and velocities were <0.5 m/s (Figure 40). Most fish were caught when water temperatures were 20-28C.

Most emerald shiners (and many other species) are captured where turbidity levels were 10 – 100 NTUs. At turbidity levels of 0 to 10 NTUs, the depth of the photic zone drops quickly from 30 m to about 4 m, but light would usually still penetrate to the bottom of most of the Missouri River. As turbidity levels increase from 10 to 50 NTUs, light penetration changes very little and the photic zone is the upper 2 – 3 m. At 100 NTUs and above, transparency is <1m. The emerald shiner, like most fish probably avoids very clear water (<10 NTUs) and very opaque water (>100 NTUs), which may explain why we found 90% of the fish at turbidity levels of 10 – 100 NTUs (Figure 40).

Most emerald shiners were caught by electrofishing and seining (Table 17 , Figure 38). Catch rates of 5 – 28 fish/seine haul reflect the abundance of this species at some locations (Table 17). Emerald shiners were abundant in all habitats except channel crossovers, which represents mid-channel habitats where depth and velocity are greatest. This information on emerald shiner agrees with that found in 1996, except that the fish was captured at a wider range of depths and velocities in 1997 than 1996.

Emerald Shiner

Table 17. Catch-Per-Unit-Effort (CPUE) for emerald shiner by gear, across macrohabitats (CHXO=Channel Cross-Over, ISB=Inside Bend, OSB=Outside Bend, SCC=Secondary Channel Connected, SCN=Secondary Channel Non-Connected, and TRM=Tributary Mouth). Catch rates are reported as #fish/100m for benthic trawl (BT) and drifting trammel net (DTN), #fish/180 degree haul for a bag seine (BS), #fish/hr for a stationary gill net (SGN), and #fish/min for electrofishing (EF). Least-impacted segment numbers = standard font. Inter-reservoir segment numbers = bold font. Channelized segment numbers = italic font. A "-" indicates that no sample was taken.

Segment	CHXO		ISB					OSB			SCC				SCN			TRM			
	BT	DTN	BS	BT	DTN	EF	SGN	BT	DTN	EF	BS	BT	DTN	EF	BS	EF	SGN	BT	DTN	EF	SGN
3	-	0.00	-	-	0.00	0.03	-	-	0.00	0.11	-	-	0.00	0.30	-	-	0.00	-	-	-	-
5	0.00	0.00	-	0.00	0.00	0.42	-	0.00	0.00	1.21	-	0.00	0.00	1.84	-	0.10	0.00	-	-	-	-
7	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00	-	0.06	0.00	0.00	-	0.00	-	0.00	-	-	-	0.00
8	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00	-	0.00	0.00	0.00	-	0.00	-	-	-	-	-	-
9	0.00	0.00	1.27	0.00	0.00	-	-	0.00	0.00	-	3.30	0.00	0.00	-	0.83	-	-	-	-	-	-
10	0.00	0.00	0.25	0.00	0.00	-	-	0.00	0.00	0.01	0.00	0.00	0.00	0.05	-	0.24	0.00	0.00	0.00	0.00	-
12	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00	0.00	0.00	-	-	-	0.00	0.00	0.00	-	-	0.00	0.00
14	0.00	0.00	-	0.00	0.00	0.09	-	0.00	0.00	0.91	0.17	0.00	0.00	0.37	0.00	0.10	0.00	-	-	0.66	0.00
15	0.02	0.00	12.2	0.00	0.00	-	0.00	0.00	0.00	5.99	2.80	0.04	0.00	1.45	-	0.13	0.00	-	-	0.85	0.00
17	0.00	0.00	7.60	0.00	0.00	0.35	0.00	0.00	0.00	0.01	-	-	-	-	-	-	-	-	-	0.75	0.00
19	0.00	0.00	-	-	-	0.92	0.00	0.00	0.00	0.01	3.50	0.00	-	0.08	-	-	-	-	0.00	1.50	0.00
22	0.00	0.00	-	0.00	0.00	2.16	0.00	0.00	0.00	0.96	-	-	-	-	0.00	0.20	0.00	0.10	0.00	0.24	0.00
23	0.00	0.00	1.00	0.05	0.00	3.17	0.00	0.00	0.00	0.74	3.50	0.00	0.00	0.88	-	-	-	0.13	0.00	1.63	0.00
25	0.00	0.00	28.1	0.00	0.00	1.80	0.00	0.00	0.00	1.16	8.80	0.00	0.00	0.25	-	-	-	0.22	0.00	0.87	0.00
27	0.00	0.00	4.87	0.00	0.00	0.22	0.00	0.00	0.00	0.20	13.0	0.07	0.00	0.32	10.8	0.48	0.00	-	-	0.44	0.00

Emerald Shiner

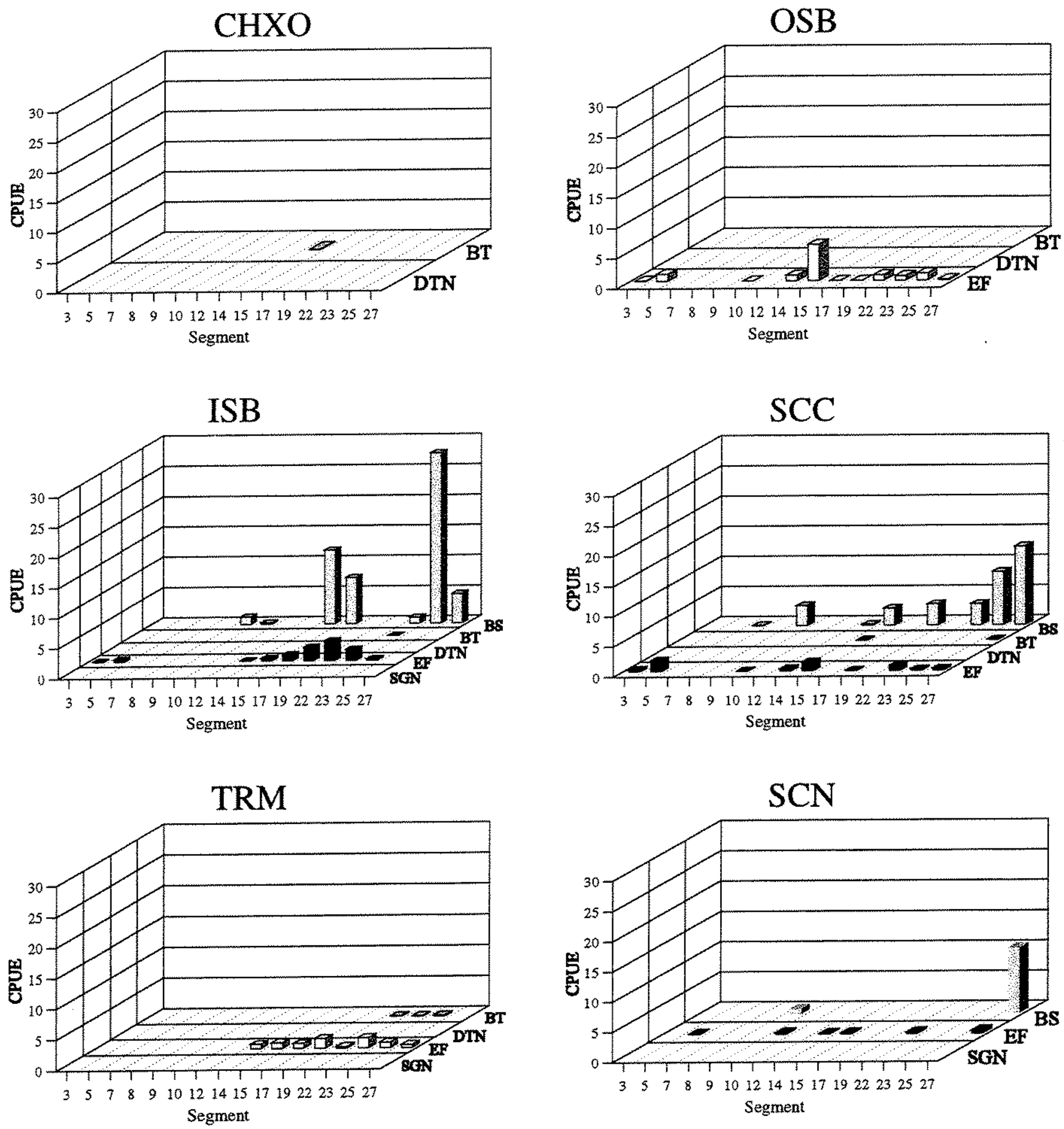
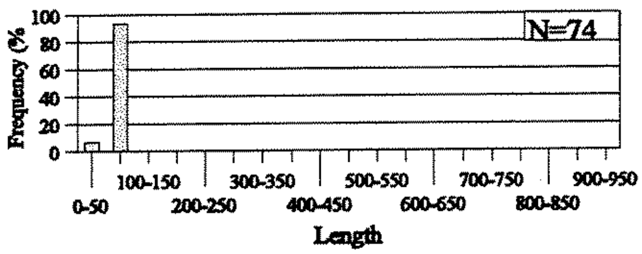


Figure 38. Trends of emerald shiner catch rates among Missouri and Yellowstone River study segments and macrohabitats in 1997. Catch rates are reported as #fish/100m for benthic trawl (BT) and drifting trammel net (DTN), #fish/180 degree haul for a bag seine (BS), #fish/hr for a statinary gill net (SGN), and #fish/min for electrofishing (EF). See Appendix A for list of macrohabitat acronyms.

Emerald Shiner

Section 1



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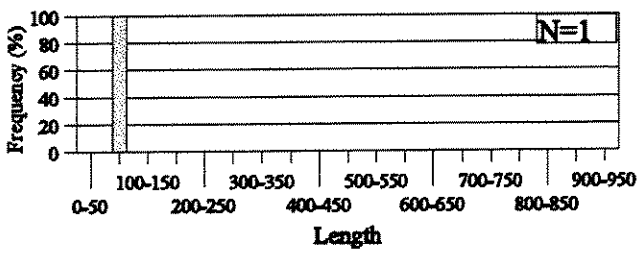

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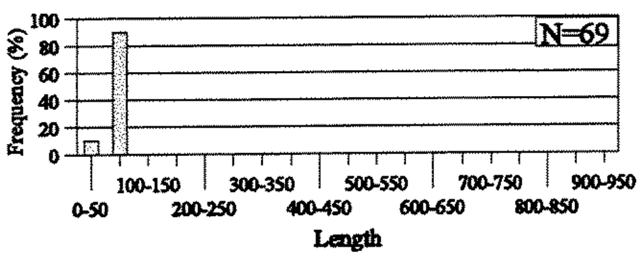

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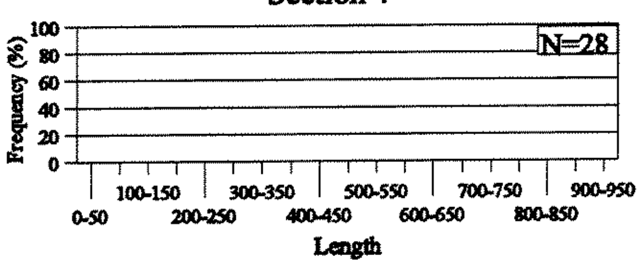

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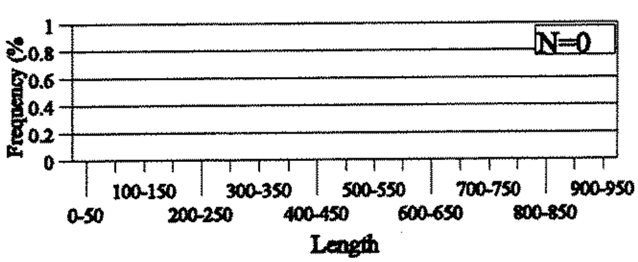

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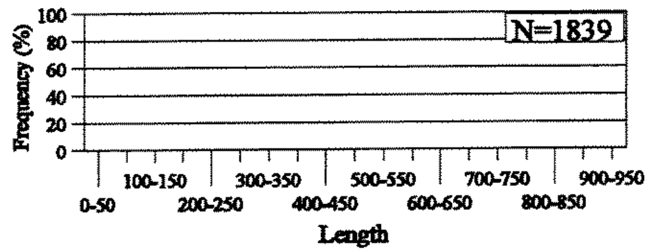

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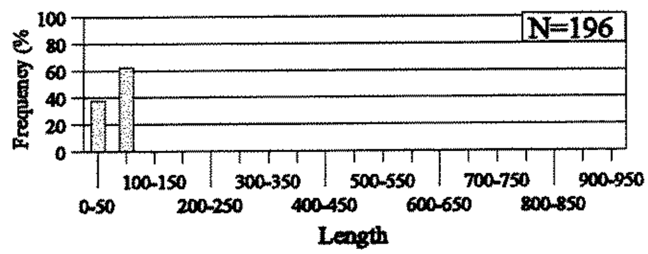

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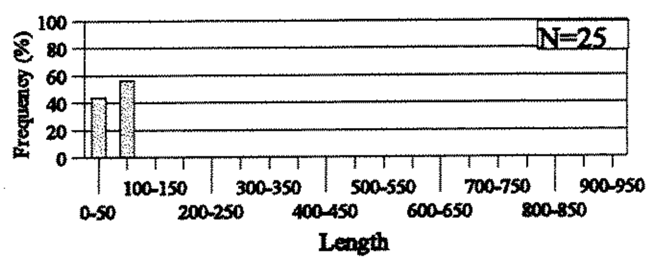


Section 9

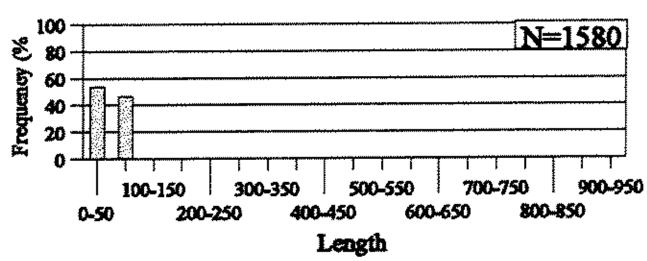


Figure 39. Length-frequency histograms of emerald shiner collected from Missouri and Yellowstone River sections using drifting trammel nets, experimental gill nets, benthic trawls, bag seines, and boat electrofishing. Remaining data will appear in 1997 Age & Growth Analyses. See Table 1 for section definitons.

Emerald Shiner

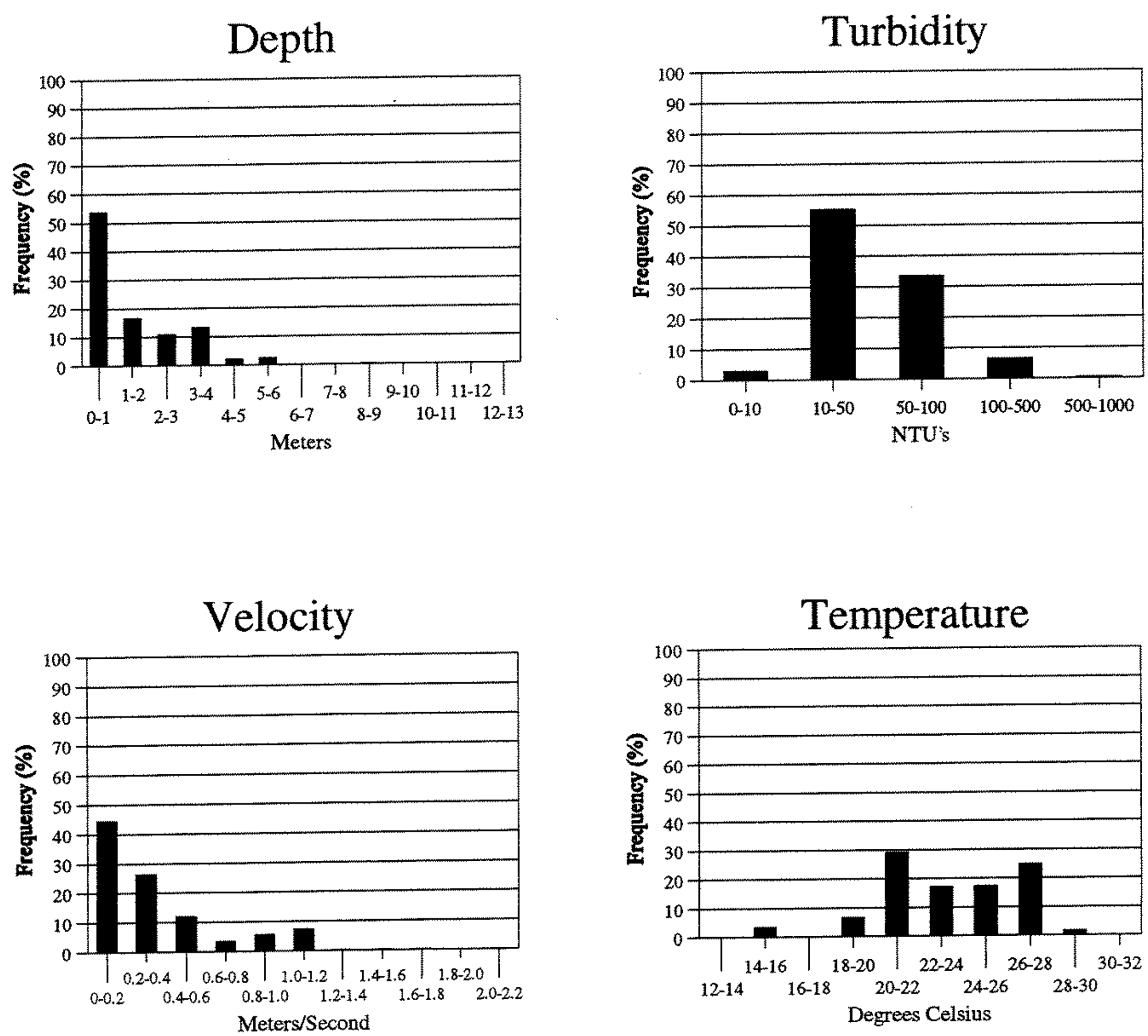


Figure 40. Frequency of occurrence of emerald shiner (N=5390) in various depth, velocity, turbidity, and water temperature intervals from Missouri and Yellowstone River collections.

Fathead minnow (FHMW)

Fathead minnows were ubiquitous but not abundant as only 219 fish were collected (Table 9). In 1996, 91% were captured in Segment 12, which also yielded high numbers in 1997 as did Segment 7. Most were less than 150-mm long, and we found the smallest size class in six of the nine river sections, indicating successful reproduction (Figure 42). The species was associated with shallow water with low flows and turbidity levels (Figure 43). About 80% of the fish were caught where water temperatures were 16-18, but some fish were caught at temperatures from 12 to 28 °C. Electrofishing and seining were the only gears that yielded fathead minnows, which were found in all habitats except channel crossovers (Figure 41, Table 18). The data generally agree with that collected in 1996, but to date <500 fish have been captured.

Fathead Minnow

Table 18. Catch-Per-Unit-Effort (CPUE) for fathead minnow by gear, across macrohabitats (CHXO=Channel Cross-Over, ISB=Inside Bend, OSB=Outside Bend, SCC=Secondary Channel Connected, SCN=Secondary Channel Non-Connected, and TRM=Tributary Mouth). Catch rates are reported as #fish/100m for benthic trawl (BT) and drifting trammel net (DTN), #fish/180 degree haul for a bag seine (BS), #fish/hr for a stationary gill net (SGN), and #fish/min for electrofishing (EF). Least-impacted segment numbers = standard font. Inter-reservoir segment numbers = bold font. Channelized segment numbers = italic font. A "-" indicates that no sample was taken.

Segment	CHXO		ISB					OSB			SCC				SCN			TRM			
	BT	DTN	BS	BT	DTN	EF	SGN	BT	DTN	EF	BS	BT	DTN	EF	BS	EF	SGN	BT	DTN	EF	SGN
3	-	0.00	-	-	0.00	0.00	-	-	0.00	0.00	-	-	0.00	0.00	-	-	0.00	-	-	-	-
5	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.00	-	-	-	-
7	0.00	0.00	0.25	0.00	0.00	-	-	0.00	0.00	-	0.00	0.00	0.00	-	11.0	-	0.00	-	-	-	0.00
8	0.00	0.00	-	0.00	0.00	-	-	0.00	0.00	-	0.00	0.00	0.00	-	0.00	-	-	-	-	-	-
9	0.00	0.00	0.07	0.00	0.00	-	-	0.00	0.00	-	0.00	0.00	0.00	-	0.00	-	-	-	-	-	-
10	0.00	0.00	-	0.00	0.00	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	0.00	0.00	0.00	0.00	0.00	-
12	0.00	0.00	0.25	0.00	0.00	-	-	0.00	0.00	0.62	0.33	-	-	-	0.67	0.00	0.00	-	-	0.03	0.00
14	0.00	0.00	-	0.00	0.00	0.02	-	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	-	-	0.02	0.00
15	0.00	0.00	-	0.00	0.00	-	0.00	0.00	0.00	-	0.56	0.00	0.00	0.00	-	0.00	0.00	-	-	0.00	0.00
17	0.00	0.00	0.30	0.00	0.00	0.00	0.00	0.00	0.00	-	-	-	-	-	-	-	-	-	-	0.02	0.00
19	0.00	0.00	-	-	-	0.00	0.00	0.00	0.00	-	0.50	0.00	-	-	-	-	-	-	0.00	0.00	0.00
22	0.00	0.00	-	0.00	0.00	0.00	0.00	0.00	0.00	0.01	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	0.00	0.00	0.00	0.01	-	-	-	0.00	0.00	0.00	0.00
25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	-	-	-	0.00	0.00	0.00	0.00
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00

Fathead Minnow

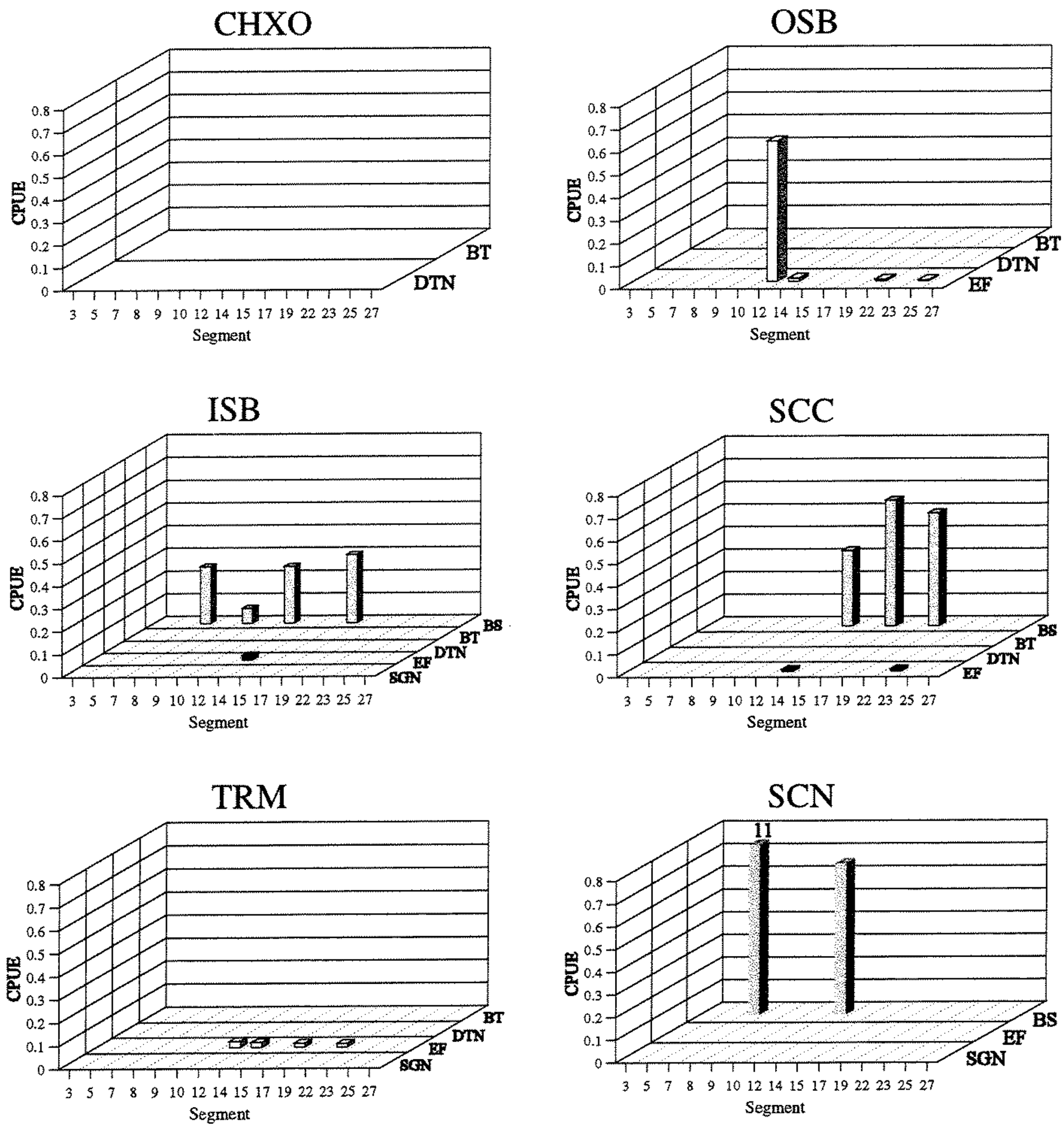


Figure 41. Trends of fathead minnow catch rates among Missouri and Yellowstone River study segments and macrohabitats in 1997. Catch rates are reported as #fish/100m for benthic trawl (BT) and drifting trammel net (DTN), #fish/180 degree haul for a bag seine (BS), #fish/hr for a statinary gill net (SGN), and #fish/min for electrofishing (EF). See Appendix A for list of macrohabitat acronyms.

Fathead Minnow

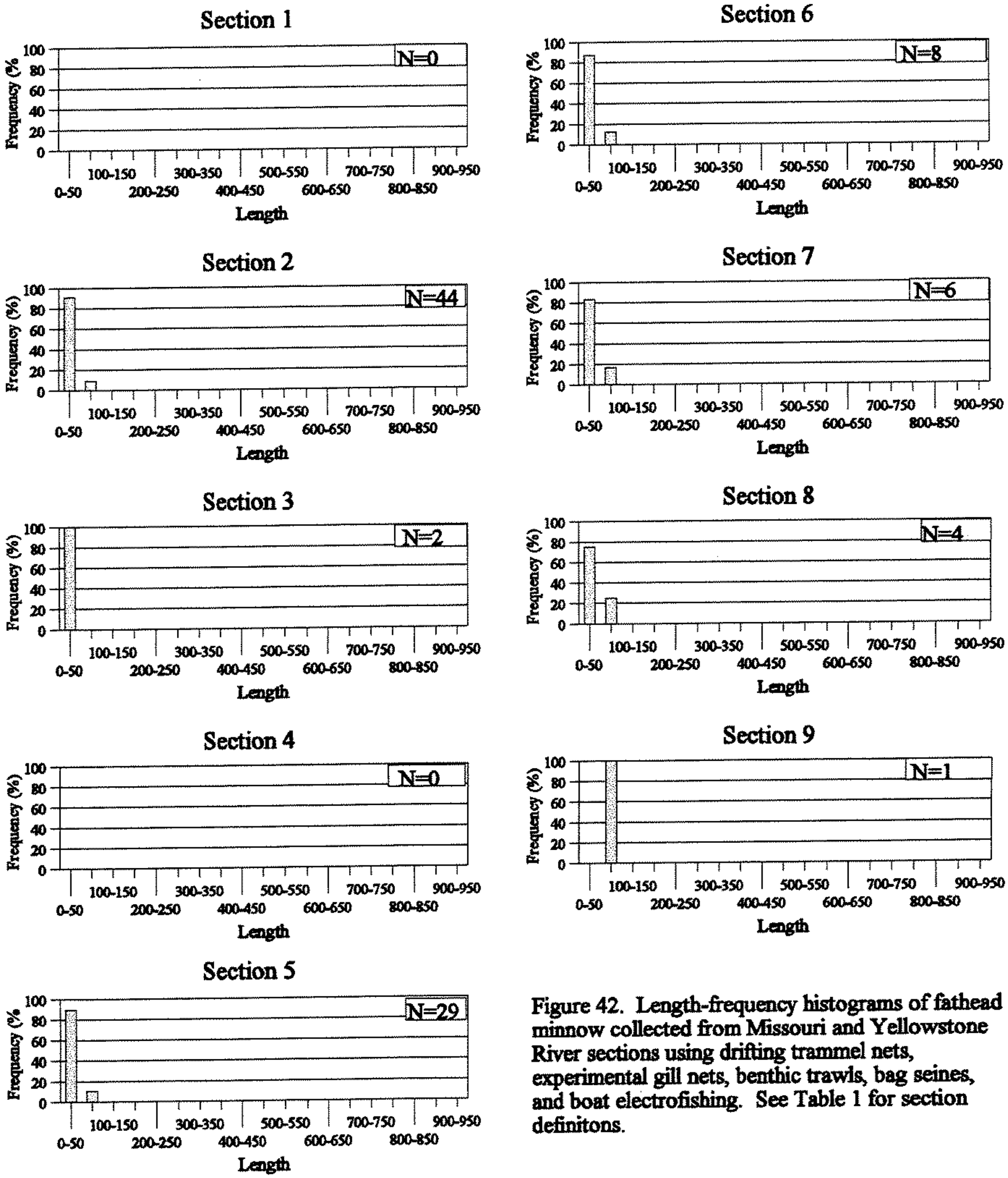


Figure 42. Length-frequency histograms of fathead minnow collected from Missouri and Yellowstone River sections using drifting trammel nets, experimental gill nets, benthic trawls, bag seines, and boat electrofishing. See Table 1 for section definitons.

Fathead Minnow

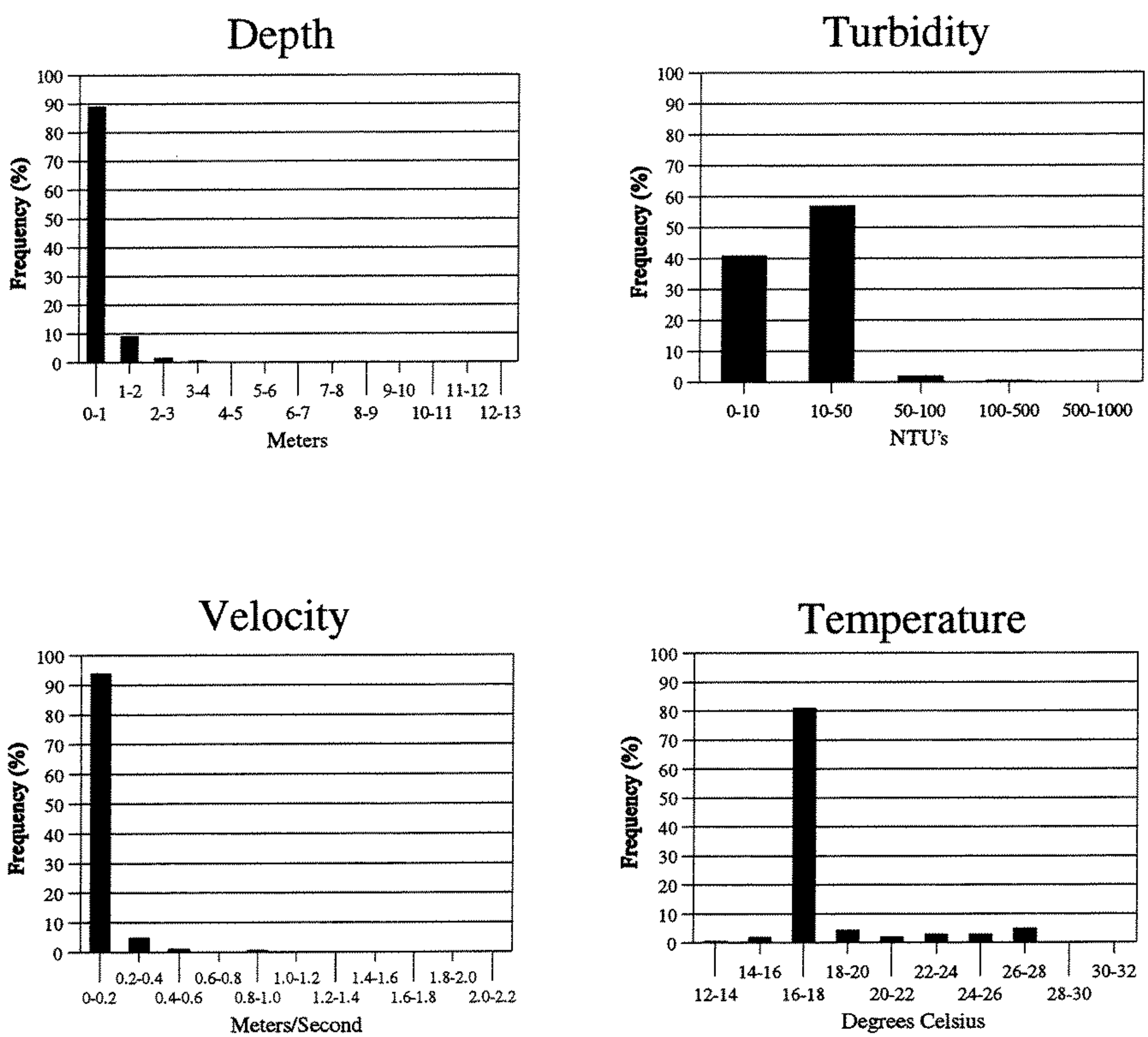


Figure 43. Frequency of occurrence of fathead minnow (N=209) in various depth, velocity, turbidity, and water temperature intervals from Missouri and Yellowstone River collections.

Flathead Catfish (FHCF)

A total of 382 flathead catfish were captured. Catches occurred in inter-reservoir segment **15** and in channelized segments *17*, *19*, *22*, *23*, *25*, and *27* (Figure 44). Fish were captured in all macrohabitats except CHXO and with the benthic trawl, electrofishing boat, and stationary gill net (Table 19). Fish were most commonly captured with the electrofishing boat in OSBs.

Most flathead catfish were collected in shallow depths (80% in depths < 3 meters), low velocities (69% in velocities < 0.6 m/s), low to intermediate turbidities (95% between 10-100 NTUs), and warm waters (73% in temperatures between 24 and 30 °C) (Figure 46). Less than 3% of flathead catfish were captured in turbidities < 10 NTUs and temperatures < 20°C.

Flathead catfish were captured only in sections 6, 7, 8, and 9, with most (40%) captured in section 8. Length frequencies in these sections ranged from 50-1150 mm (Figure 45). Sections 8 and 9 had the highest proportions of fish <100 mm (16% and 11%).

Flathead Catfish

Table 19. Catch-Per-Unit-Effort (CPUE) for flathead catfish by gear, across macrohabitats (CHXO=Channel Cross-Over, ISB=Inside Bend, OSB=Outside Bend, SCC=Secondary Channel Connected, SCN=Secondary Channel Non-Connected, and TRM=Tributary Mouth). Catch rates are reported as #fish/100m for benthic trawl (BT) and drifting trammel net (DTN), #fish/180 degree haul for a bag seine (BS), #fish/hr for a stationary gill net (SGN), and #fish/min for electrofishing (EF). Least-impacted segment numbers = standard font. Inter-reservoir segment numbers = bold font. Channelized segment numbers = italic font. A "-" indicates that no sample was taken.

Segment	CHXO		ISB					OSB			SCC				SCN			TRM			
	BT	DTN	BS	BT	DTN	EF	SGN	BT	DTN	EF	BS	BT	DTN	EF	BS	EF	SGN	BT	DTN	EF	SGN
3	-	0.00	-	-	0.00	0.00	-	-	0.00	0.00	-	-	0.00	0.00	-	-	0.00	-	-	-	-
5	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.00	-	-	-	-
7	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00	-	0.00	0.00	0.00	-	0.00	-	0.00	-	-	-	0.00
8	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00	-	0.00	0.00	0.00	-	0.00	-	-	-	-	-	-
9	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00	-	0.00	0.00	0.00	-	0.00	-	-	-	-	-	-
10	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	0.00	0.00	0.00	0.00	0.00	-
12	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00	0.00	0.00	-	-	-	0.00	0.00	0.00	-	-	0.00	0.00
14	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	-	-	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	-	0.00	0.00	0.00	0.26	0.00	0.00	0.00	0.11	-	0.00	0.00	-	-	0.04	0.01
17	0.00	0.00	0.00	0.00	0.00	0.10	0.01	0.00	0.00	0.24	-	-	-	-	-	-	-	-	-	0.01	0.00
19	0.00	0.00	-	-	-	0.35	0.01	0.00	0.00	0.35	0.00	0.00	-	0.00	-	-	-	-	0.00	0.01	0.00
22	0.00	0.00	-	0.00	0.00	0.11	0.00	0.00	0.00	0.41	-	-	-	-	0.00	0.00	0.42	0.00	0.00	0.02	0.00
23	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.44	0.00	0.08	0.00	0.04	-	-	-	0.00	0.00	0.05	0.01
25	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.16	0.00	0.13	0.00	0.01	-	-	-	0.00	0.00	0.03	0.01
27	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.24	0.00	0.00	0.00	0.03	0.00	0.05	0.00	-	-	0.00	0.00

Flathead Catfish

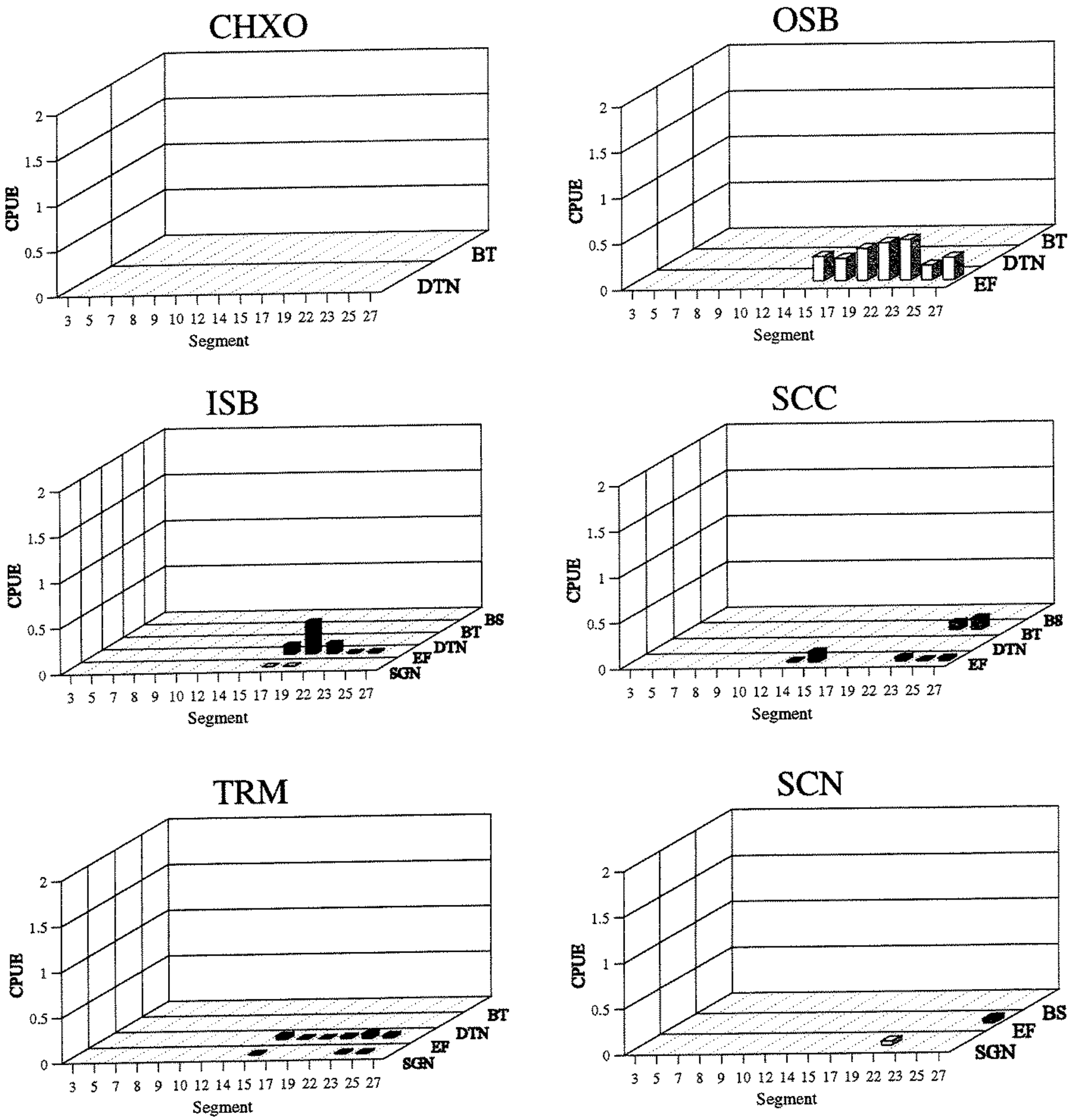
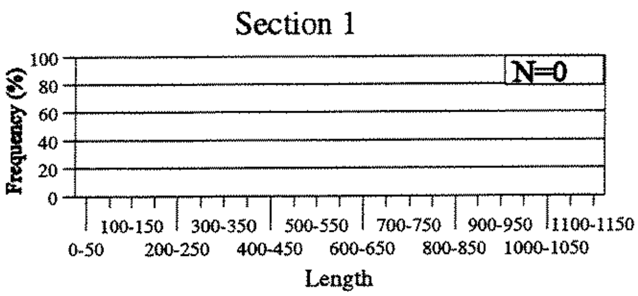
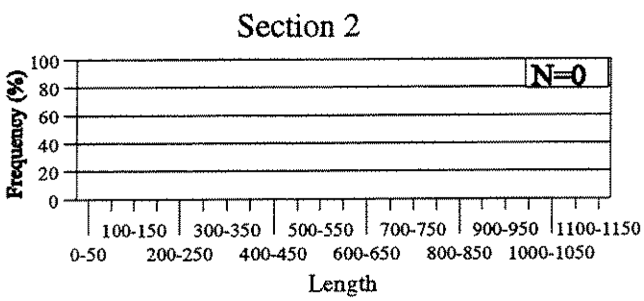
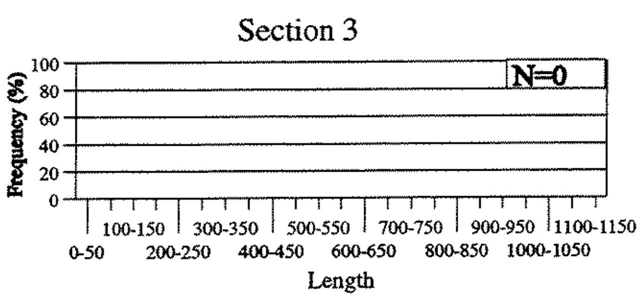


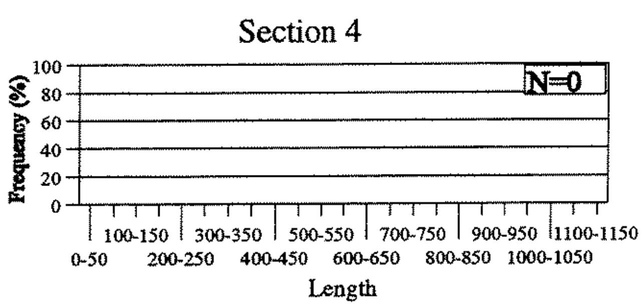
Figure 44. Trends of flathead catfish catch rates among Missouri and Yellowstone River study segments and macrohabitats in 1997. Catch rates are reported as #fish/100m for benthic trawl (BT) and drifting trammel net (DTN), #fish/180 degree haul for a bag seine (BS), #fish/hr for a statinary gill net (SGN), and #fish/min for electrofishing (EF). See Appendix A for list of macrohabitat acronyms.

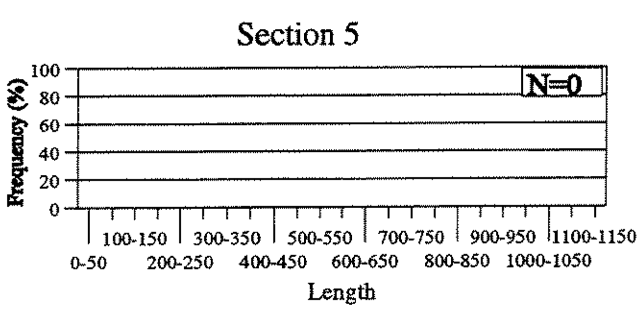
Flathead Catfish

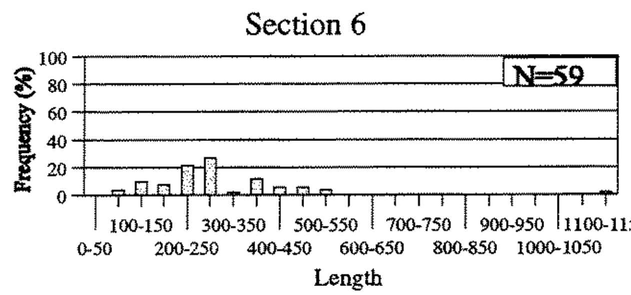


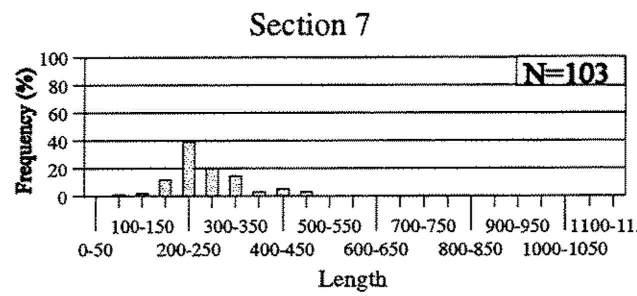


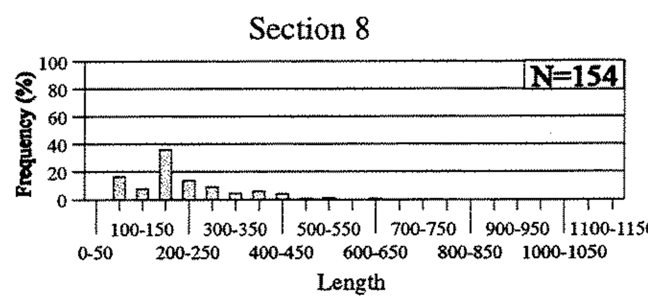












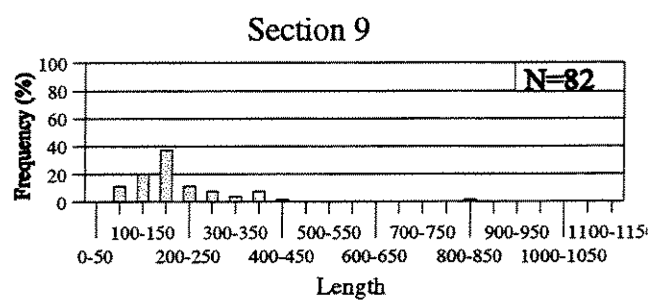


Figure 45. Length-frequency histograms of flathead catfish collected from Missouri and Yellowstone River sections using drifting trammel nets, experimental gill nets, benthic trawls, bag seines, and boat electrofishing. See Table 1 for section definitons.

Flathead Catfish

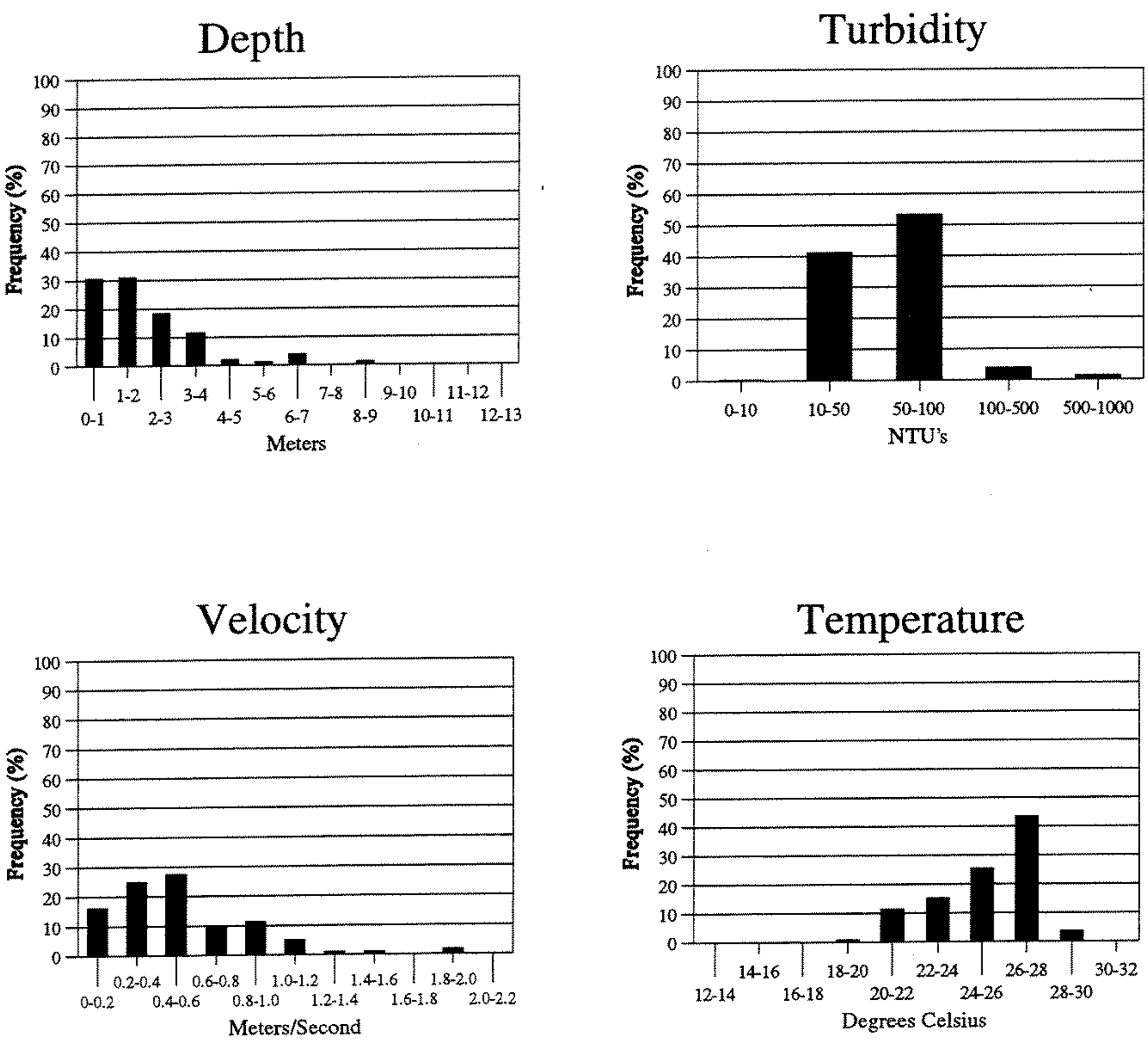


Figure 46. Frequency of occurrence of flathead catfish (N=382) in various depth, velocity, turbidity, and water temperature intervals from Missouri and Yellowstone River collections.

Flathead chub (FHCB)

Flathead chub was the third most abundant fish in the benthic guild. Its distribution was skewed toward the upper river, and the catch rate declined from hundreds of fish collected at segments 3 – 10 (Segment 10 ends at the headwaters of Lake Sakakawea) to less than 10 fish collected at segments 11 – 27 (Table 9). This pattern agrees with data from 1996. Some chubs were 300-mm long and there was usually a good representation of several length groups at most sections, especially Sections 2, 3, and 4 in the upper river where the fish were most numerous (Figure 48).

Most flathead chubs were captured where depths were <1 m, where velocities were <0.4 m/s, and where temperature was between 14 and 26 C. Flathead chubs tended to be captured in colder water than some other species, and in more turbid water. About 40% were captured where turbidity readings exceeded 100 NTUs, so light penetration at these sites was probably <1 m. Most chubs were captured at inside bends and in connected secondary channels (Figure 49). The bag seine was the most effective collection gear with CPUE values up to 44 fish/seine haul (Table 20), but some chubs were caught in every gear (Figure 47). This summary of flathead chub abundance and habitat association is very similar to that suggested by the 1996 data.

Flathead Chub

Table 20. Catch-Per-Unit-Effort (CPUE) for flathead chub by gear, across macrohabitats (CHXO=Channel Cross-Over, ISB=Inside Bend, OSB=Outside Bend, SCC=Secondary Channel Connected, SCN=Secondary Channel Non-Connected, and TRM=Tributary Mouth). Catch rates are reported as #fish/100m for benthic trawl (BT) and drifting trammel net (DTN), #fish/180 degree haul for a bag seine (BS), #fish/hr for a stationary gill net (SGN), and #fish/min for electrofishing (EF). Least-impacted segment numbers = standard font. Inter-reservoir segment numbers = bold font. Channelized segment numbers = italic font. A "-" indicates that no sample was taken.

Segment	CHXO		ISB					OSB			SCC				SCN			TRM			
	BT	DTN	BS	BT	DTN	EF	SGN	BT	DTN	EF	BS	BT	DTN	EF	BS	EF	SGN	BT	DTN	EF	SGN
3	-	0.04	-	-	0.04	0.30	-	-	0.02	0.29	-	-	0.00	0.30	-	-	0.00	-	-	-	-
5	0.00	0.08	-	0.18	0.03	0.58	-	0.03	0.12	1.07	-	0.13	0.12	0.14	-	0.10	0.00	-	-	-	-
7	0.02	0.00	2.58	0.02	0.02	-	-	0.04	0.00	-	0.72	0.02	0.09	-	0.00	-	0.00	-	-	-	0.00
8	0.04	0.00	5.44	0.04	0.04	-	-	0.02	0.00	-	2.48	0.03	0.03	-	0.00	-	-	-	-	-	-
9	0.13	0.02	44.0	0.09	0.00	-	-	0.07	0.00	-	35.1	0.33	0.05	-	50.2	-	-	-	-	-	-
10	0.00	0.00	18.5	0.07	0.00	-	-	0.00	0.00	0.19	17.0	0.00	0.00	0.50	-	0.00	0.00	0.00	0.00	1.45	-
12	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00	0.00	0.00	-	-	-	0.00	0.00	0.00	-	-	0.00	0.00
14	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	-	0.00	0.00	0.00	0.00	0.26	0.00	0.00	0.00	-	0.00	0.00	-	-	0.00	0.00
17	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	-	-	-	-	-	-	-	0.00	0.00
19	0.00	0.00	-	-	-	0.00	0.00	0.00	0.00	0.00	0.50	0.00	-	0.00	-	-	-	-	0.00	0.00	0.00
22	0.00	0.00	-	0.00	0.00	0.02	0.00	0.00	0.00	0.01	-	-	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	-	-	-	0.00	0.00	0.00	0.00
25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	-	-	-	0.00	0.00	0.00	0.00
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00

Flathead Chub

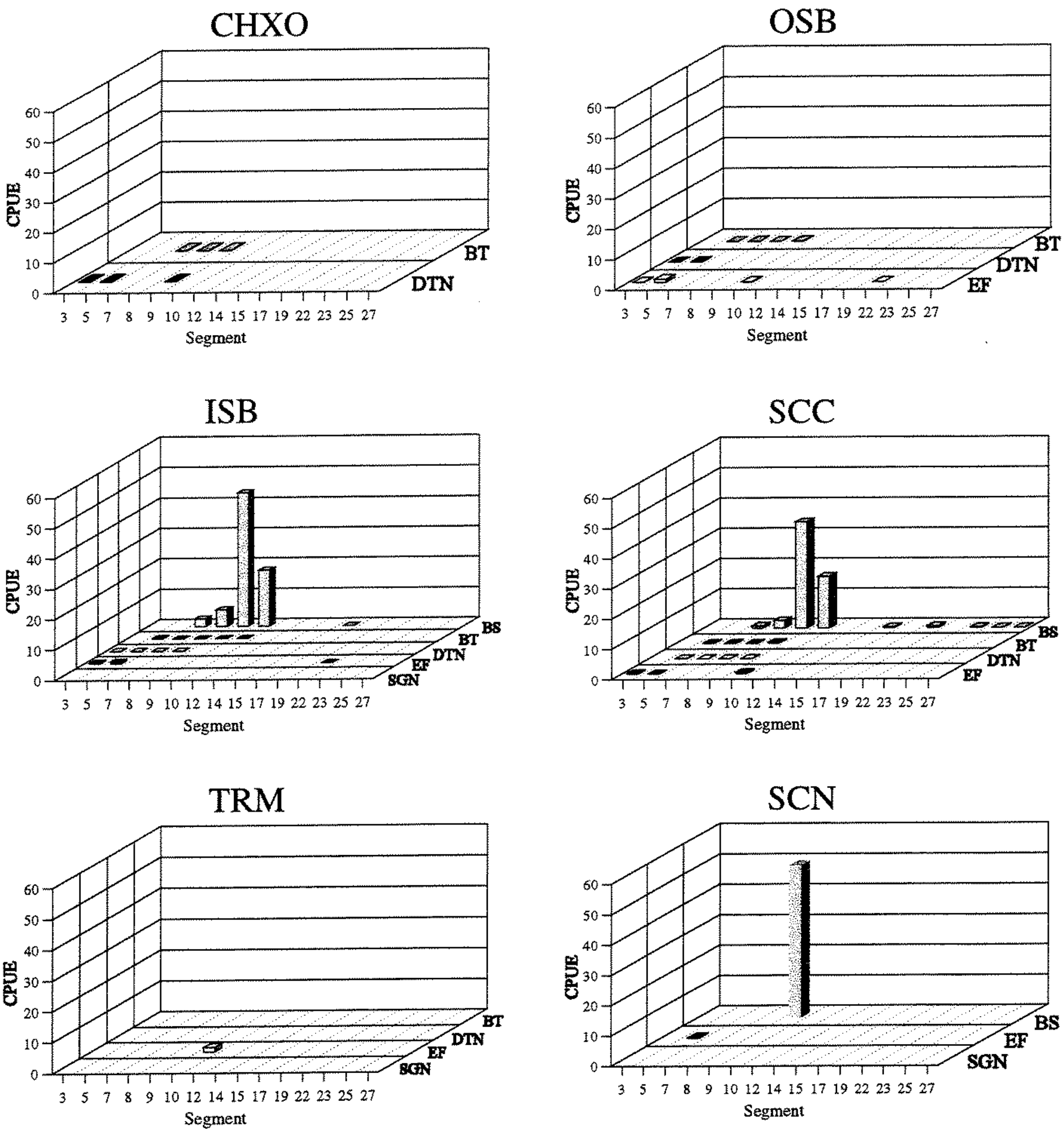
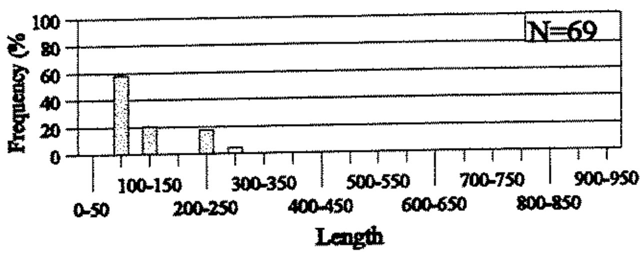


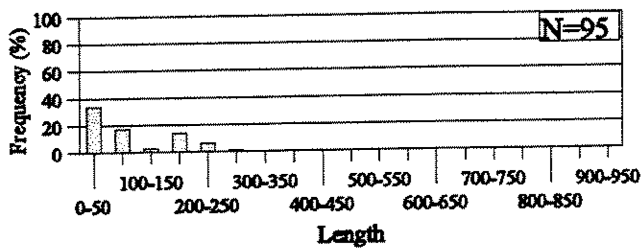
Figure 47. Trends of flathead chub catch rates among Missouri and Yellowstone River study segments and macrohabitats in 1997. Catch rates are reported as #fish/100m for benthic trawl (BT) and drifting trammel net (DTN), #fish/180 degree haul for a bag seine (BS), #fish/hr for a statinary gill net (SGN), and #fish/min for electrofishing (EF). See Appendix A for list of macrohabitat acronyms.

Flathead Chub

Section 1



Section 2



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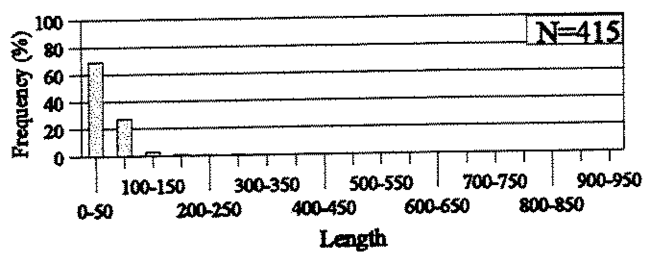

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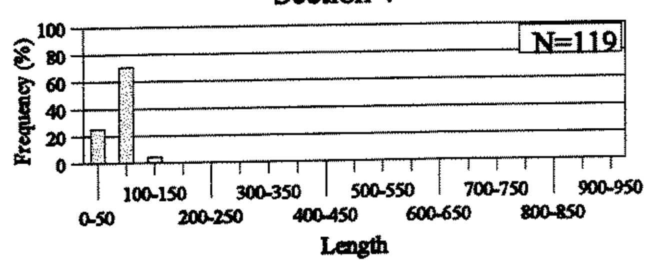

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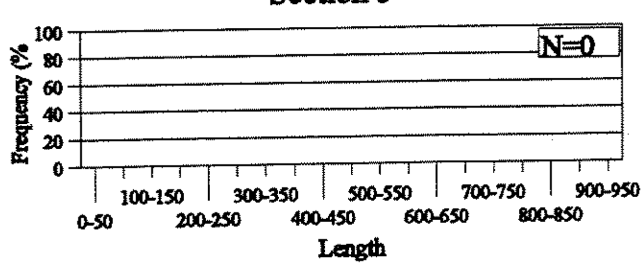
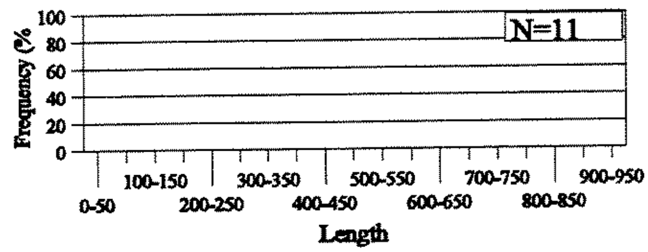


Section 6



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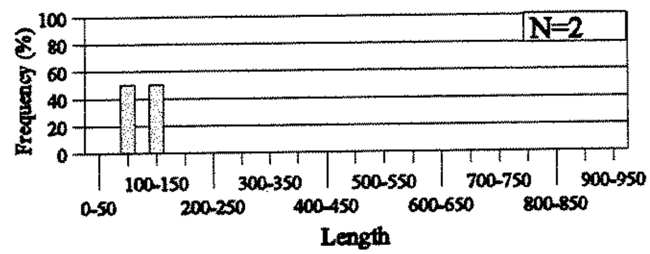

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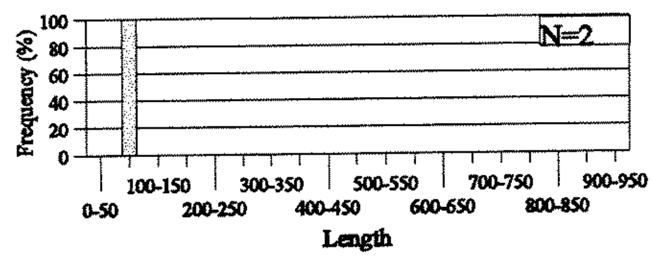


Section 9

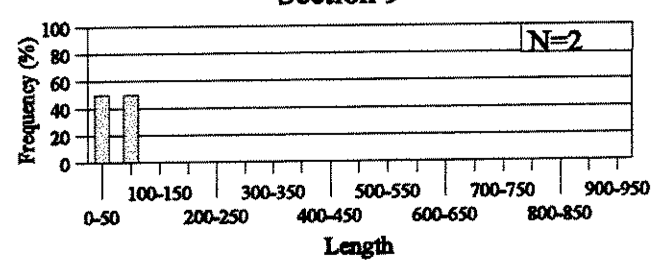


Figure 48. Length-frequency histograms of flathead chub collected from Missouri and Yellowstone River sections using drifting trammel nets, experimental gill nets, benthic trawls, bag seines, and boat electrofishing. Remaining data will appear in 1997 Age & Growth Analyses. See Table 1 for section definitons.

Flathead Chub

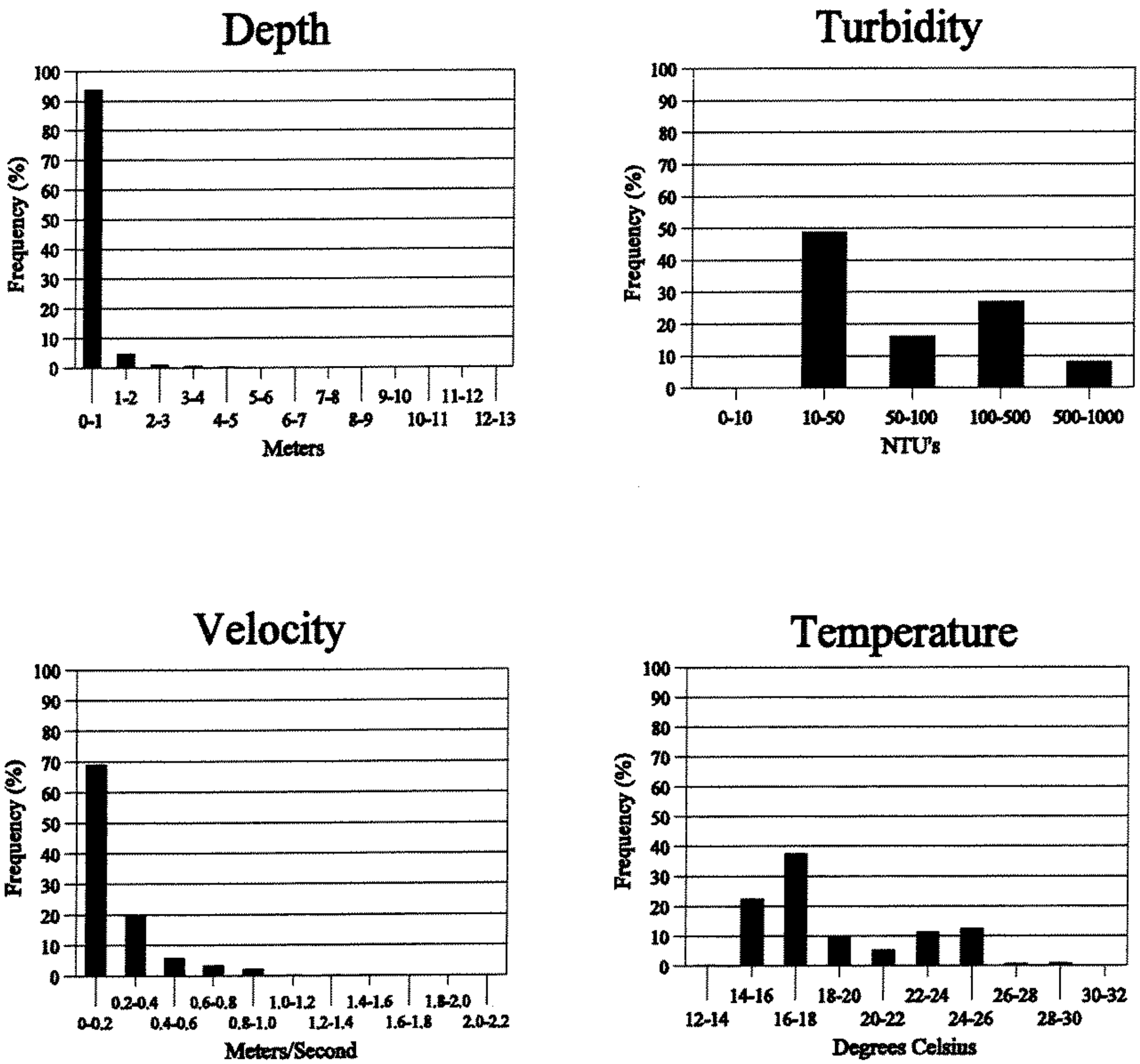


Figure 49. Frequency of occurrence of flathead chub (N=3421) in various depth, velocity, turbidity, and water temperature intervals from Missouri and Yellowstone River collections.

Freshwater drum (FWDM)

A total of 917 freshwater drum was captured in 1997 with most fish (74%) captured in the lower channelized segments *17* to *27* below Gavins Point Dam. Freshwater drum were captured in all macrohabitats, except CHXO, and with every gear except the drifting trammel net (Figure 50). Highest catch rates were obtained in segment *22* with the benthic trawl in TRM (16.77/100 m) (Table 21). No freshwater drum were captured in inter-reservoir segments **7** or **12**. Most freshwater drum were captured in shallow water (90% in depths < 3 m) and low current velocities (80% in velocities < 0.4 m/s) (Figure 52). Fish were captured most frequently in low to intermediate turbidities (76% between 10-100 NTUs) and warm waters (78% in temperatures > 22°C). Less than 10% of all freshwater drum were captured in depths greater than 3 m or velocities greater than 0.6 m/s.

Length-frequency distributions were irregular in most sections suggesting that recruitment was erratic or that fish were not recruited to our gears (Figure 51). Declining length frequencies were found in sections 6, 8, and 9, however, few fish 0-50 mm in length were found. No freshwater drum were captured in section 5 (Garrison Dam to Lake Oahe headwaters).

Freshwater Drum

Table 21. Catch-Per-Unit-Effort (CPUE) for freshwater drum by gear, across macrohabitats (CHXO=Channel Cross-Over, ISB=Inside Bend, OSB=Outside Bend, SCC=Secondary Channel Connected, SCN=Secondary Channel Non-Connected, and TRM=Tributary Mouth). Catch rates are reported as #fish/100m for benthic trawl (BT) and drifting trammel net (DTN), #fish/180 degree haul for a bag seine (BS), #fish/hr for a stationary gill net (SGN), and #fish/min for electrofishing (EF). Least-impacted segment numbers = standard font. Inter-reservoir segment numbers = bold font. Channelized segment numbers = italic font. A "-" indicates that no sample was taken.

Segment	CHXO		ISB					OSB			SCC				SCN			TRM			
	BT	DTN	BS	BT	DTN	EF	SGN	BT	DTN	EF	BS	BT	DTN	EF	BS	EF	SGN	BT	DTN	EF	SGN
3	-	0.00	-	-	0.00	0.30	-	-	0.00	0.37	-	-	0.00	0.20	-	-	0.00	-	-	-	-
5	0.00	0.00	-	0.00	0.00	0.02	-	0.00	0.00	0.25	-	0.00	0.00	0.03	-	0.00	0.00	-	-	-	-
7	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00	-	0.00	0.00	0.00	-	0.00	-	0.00	-	-	-	0.00
8	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00	-	0.03	0.00	0.00	-	0.00	-	-	-	-	-	-
9	0.00	0.00	0.13	0.00	0.00	-	-	0.00	0.00	-	0.00	0.00	0.00	-	0.00	-	-	-	-	-	-
10	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00	0.01	0.00	0.00	0.00	0.00	-	0.00	0.00	0.00	0.00	0.00	-
12	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00	0.00	0.00	-	-	-	0.00	0.00	0.00	-	-	0.00	0.00
14	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	-	-	0.04	0.00
15	0.00	0.00	0.13	0.00	0.00	-	0.01	0.00	0.00	0.05	0.04	0.00	0.00	0.01	-	0.15	0.00	-	-	0.42	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	-	-	-	-	-	-	-	0.02	0.02
19	0.00	0.00	-	-	-	0.00	0.01	0.00	0.00	0.01	0.00	0.17	-	0.05	-	-	-	-	0.00	0.01	0.05
22	0.00	0.00	-	0.00	0.00	0.03	0.00	0.00	0.00	0.02	-	-	-	-	0.50	0.37	0.02	16.8	0.00	0.79	0.03
23	0.00	0.00	0.00	0.05	0.00	0.01	0.01	0.00	0.00	0.62	0.00	0.00	0.00	0.04	-	-	-	0.00	0.00	0.62	0.06
25	0.00	0.00	0.47	0.58	0.00	0.05	0.00	0.00	0.00	0.10	0.26	0.00	0.00	0.03	-	-	-	3.33	0.00	0.08	0.02
27	0.00	0.00	0.33	0.00	0.00	0.18	0.01	0.00	0.00	0.19	0.43	0.55	0.00	0.05	0.80	0.11	0.02	-	-	0.04	0.02

Freshwater Drum

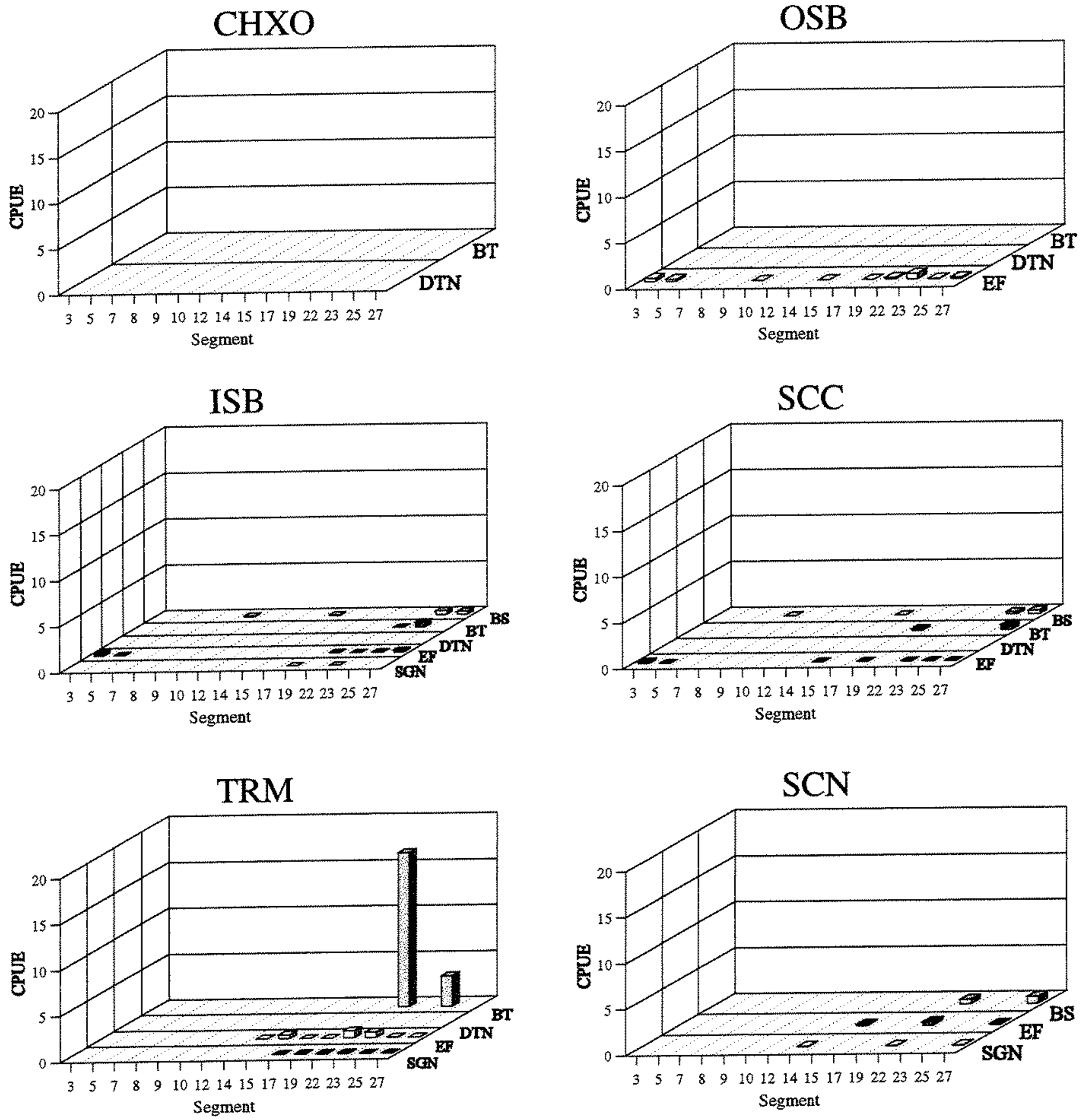
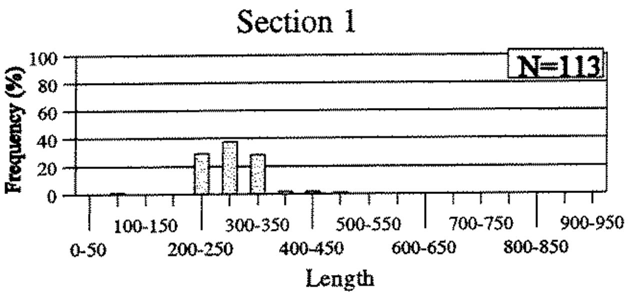
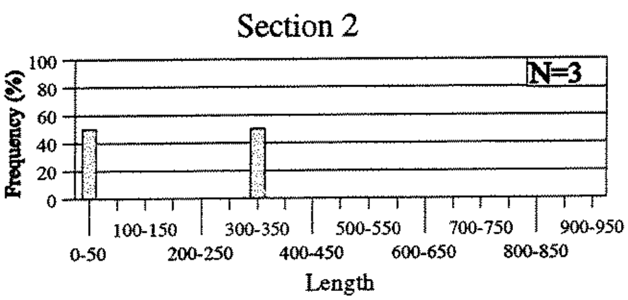
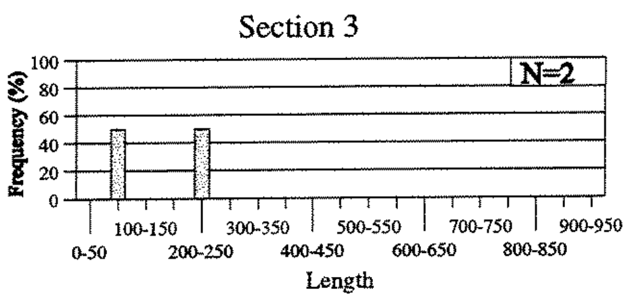


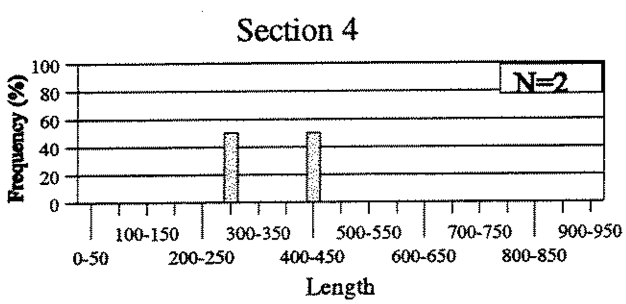
Figure 50. Trends of freshwater drum catch rates among Missouri and Yellowstone River study segments and macrohabitats in 1997. Catch rates are reported as #fish/100m for benthic trawl (BT) and drifting trammel net (DTN), #fish/180 degree haul for a bag seine (BS), #fish/hr for a statinary gill net (SGN), and #fish/min for electrofishing (EF). See Appendix A for list of macrohabitat acronyms.

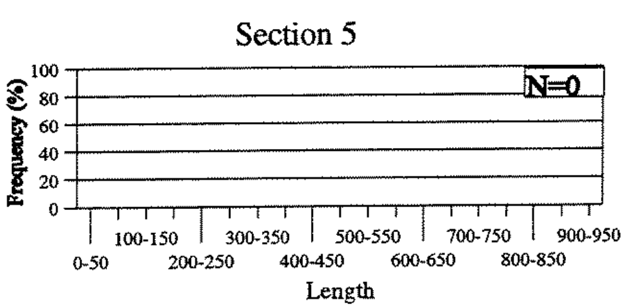
Freshwater Drum

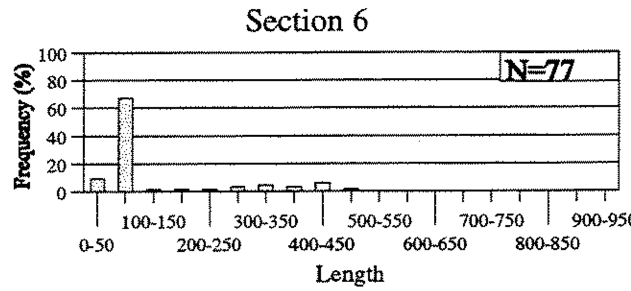


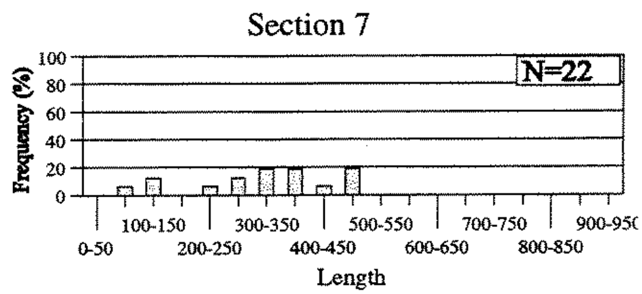


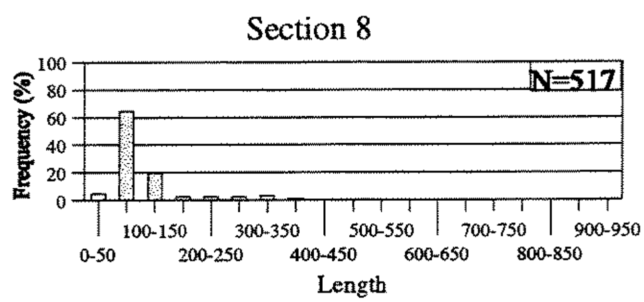












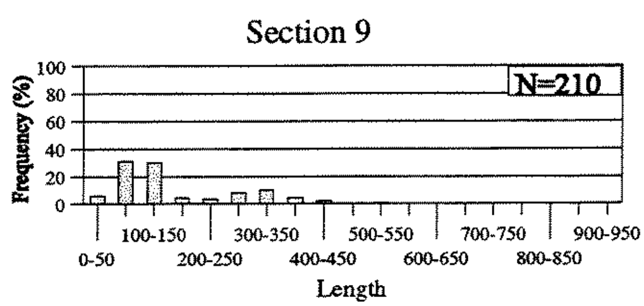


Figure 51. Length-frequency histograms of freshwater drum collected from Missouri and Yellowstone River sections using drifting trammel nets, experimental gill nets, benthic trawls, bag seines, and boat electrofishing. See Table 1 for section definitons.

Freshwater Drum

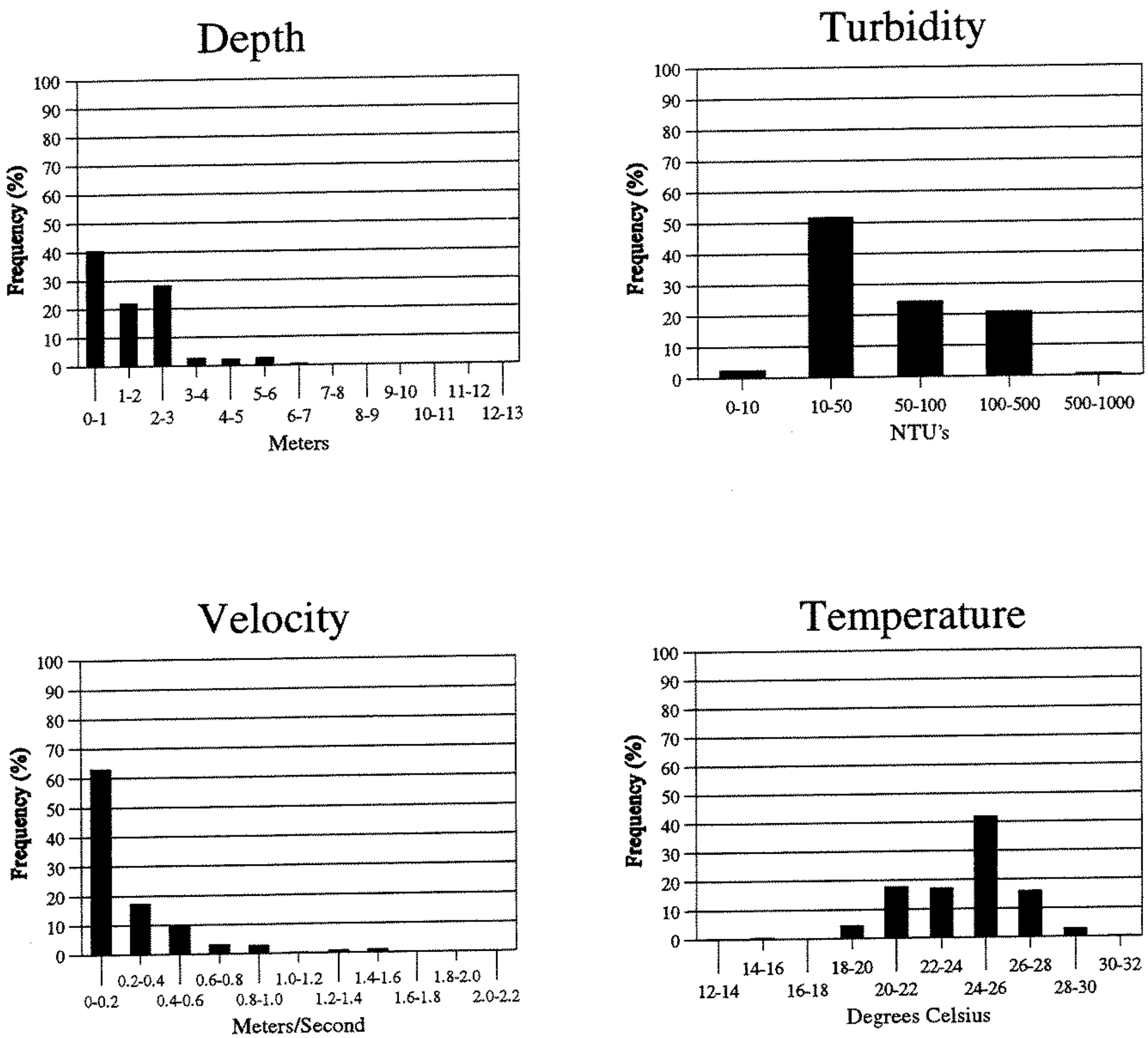


Figure 52. Frequency of occurrence of freshwater drum (N=917) in various depth, velocity, turbidity, and water temperature intervals from Missouri and Yellowstone River collections.

Hybognathus spp. (HBNS)

This group of similar species (western silvery minnow, plains minnow, brassy minnow) was widely distributed, but absent from inter-reservoir segments 12 – 15. This finding is contradictory to that in 1996 when fish were found at these sites, especially Segment 15 (Gavins Point Dam to Ponca, Nebraska). These species are small fish, so our finding that the largest specimens were only about 150-mm long was expected. There was representation of several size classes in sections 2, 5, and 9 (Figure 54). This generalization may change when data on size classes become available for sections where fish were not measured in the field. Most fish were found in shallow, low-flow areas with a wide range of water temperatures (Figure 55). About 20% were collected where light penetration was nil , but many were also collected where light penetration was great (Figure 55), perhaps indicating that this group is tolerant of a wide range of turbidity and temperature conditions. This group was found in all habitats, especially inside bends and secondary connected channels, and was vulnerable to electrofishing, seining, and trawling (Figure 53) . Seining CPUE values sometimes exceeded 50 fish/haul in secondary connected channels (Table 22). The 1997 data agreed nicely with that summarized from the 1,759 fish collected in 1996.

Hybognathus spp.

Table 22. Catch-Per-Unit-Effort (CPUE) for *Hybognathus spp.* by gear, across macrohabitats (CHXO=Channel Cross-Over, ISB=Inside Bend, OSB=Outside Bend, SCC=Secondary Channel Connected, SCN=Secondary Channel Non-Connected, and TRM=Tributary Mouth). Catch rates are reported as #fish/100m for benthic trawl (BT) and drifting trammel net (DTN), #fish/180 degree haul for a bag seine (BS), #fish/hr for a stationary gill net (SGN), and #fish/min for electrofishing (EF). Least-impacted segment numbers = standard font. Inter-reservoir segment numbers = bold font. Channelized segment numbers = italic font. A "-" indicates that no sample was taken.

Segment	CHXO		ISB					OSB			SCC				SCN			TRM			
	BT	DTN	BS	BT	DTN	EF	SGN	BT	DTN	EF	BS	BT	DTN	EF	BS	EF	SGN	BT	DTN	EF	SGN
3	-	0.00	-	-	0.00	0.00	-	-	0.00	0.00	-	-	0.00	0.05	-	-	0.00	-	-	-	-
5	0.04	0.00	-	0.08	0.00	0.12	-	0.04	0.00	0.44	-	0.00	0.00	0.13	-	0.00	0.00	-	-	-	-
7	0.00	0.00	1.00	0.00	0.00	-	-	0.00	0.00	-	0.50	0.00	0.00	-	0.44	-	0.00	-	-	-	0.00
8	0.00	0.00	0.11	0.00	0.00	-	-	0.00	0.00	-	0.42	0.00	0.00	-	0.11	-	-	-	-	-	-
9	0.09	0.00	6.87	0.06	0.00	-	-	0.00	0.00	-	8.73	0.00	0.00	-	17.7	-	-	-	-	-	-
10	0.00	0.00	3.50	0.00	0.00	-	-	0.00	0.00	0.02	18.4	0.00	0.00	0.00	-	0.18	0.00	0.00	0.00	0.00	-
12	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00	0.00	0.00	-	-	-	0.00	0.00	0.00	-	-	0.00	0.00
14	0.00	0.00	-	0.00	0.00	0.02	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00
15	0.00	0.00	0.07	0.00	0.00	-	0.00	0.00	0.00	0.01	0.33	0.00	0.00	0.01	-	0.00	0.00	-	-	0.01	0.00
17	0.00	0.00	1.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	-	-	-	-	-	-	-	0.00	0.00
19	0.00	0.00	-	-	-	0.00	0.00	0.00	0.00	0.00	98.0	0.00	-	0.00	-	-	-	-	0.00	0.09	0.00
22	0.00	0.00	-	0.03	0.00	0.33	0.00	0.00	0.00	0.43	-	-	-	-	5.50	11.6	0.00	0.00	0.00	0.04	0.00
23	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.01	59.1	0.03	0.00	0.03	-	-	-	0.00	0.00	0.02	0.00
25	0.00	0.00	1.67	0.00	0.00	0.05	0.00	0.00	0.00	0.00	65.3	0.00	0.00	0.08	-	-	-	0.11	0.00	0.01	0.00
27	0.00	0.00	1.07	0.00	0.00	0.01	0.00	0.00	0.00	0.01	9.87	0.00	0.00	0.00	1.33	0.00	0.00	-	-	0.00	0.00

Hybognathus spp.

Western Silvery Minnow, Plains Minnow, Brassy Minnow

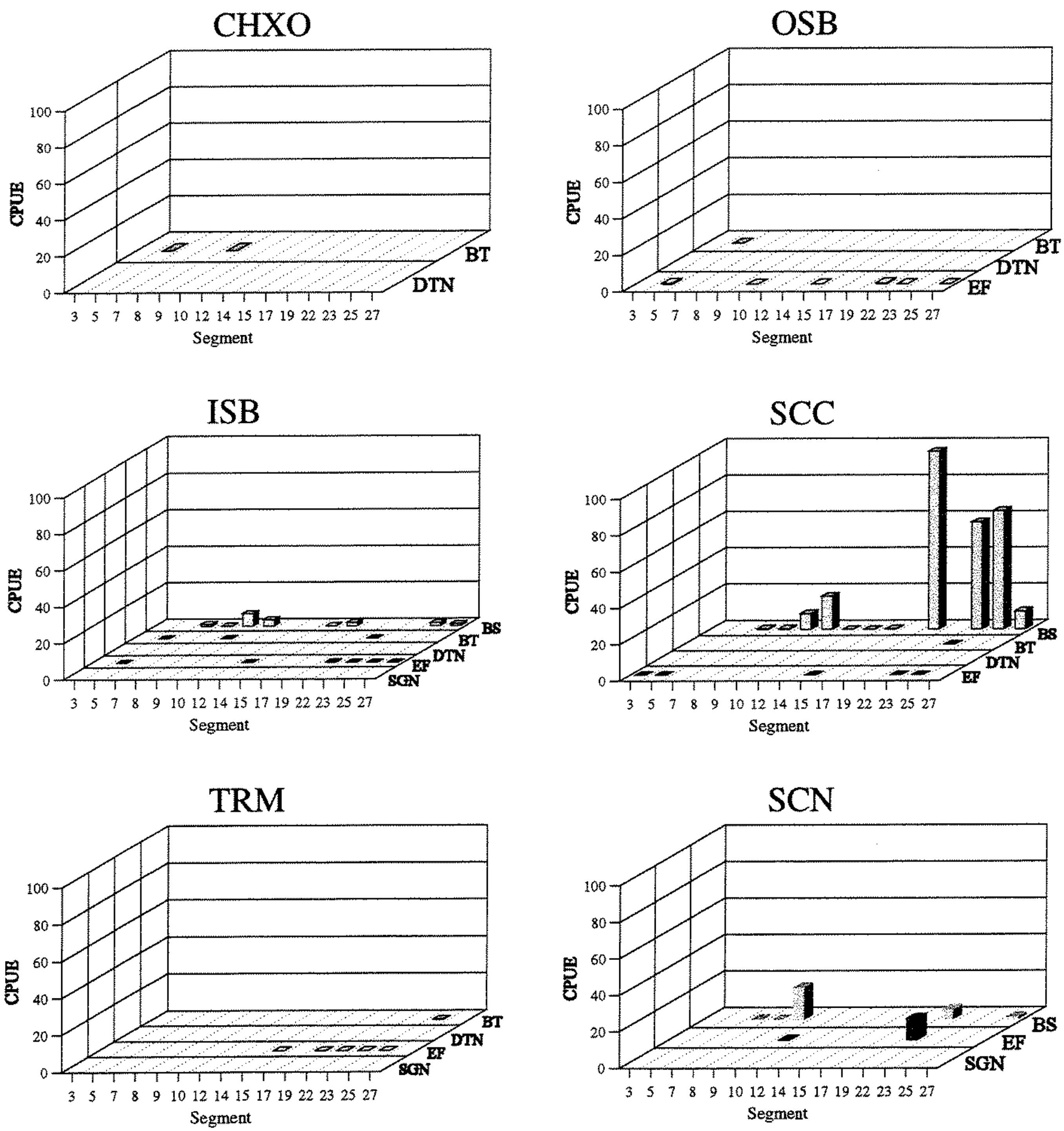
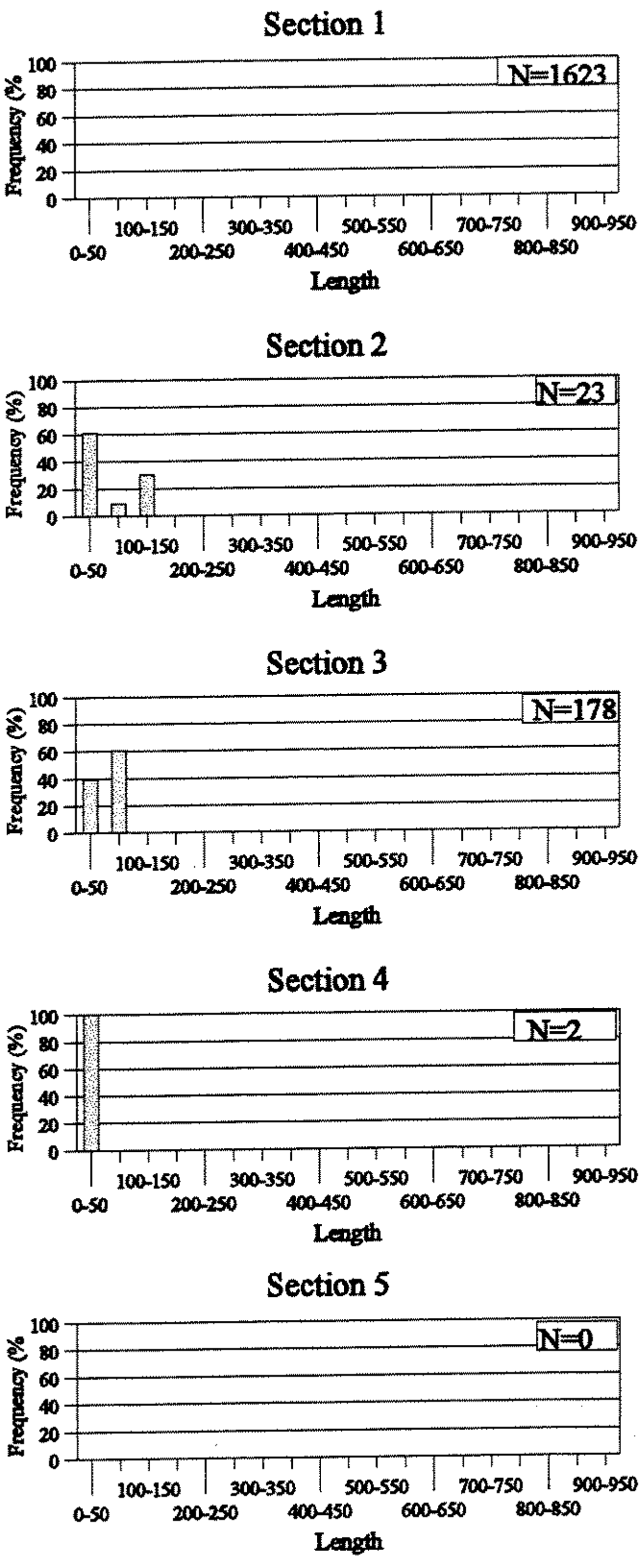


Figure 53. Trends of *Hybognathus spp.* catch rates among Missouri and Yellowstone River study segments and macrohabitats in 1997. This graph only shows species reported as Hybognathus spp. Any specific W. Silvery Minnow, Plains Minnow, or Brassy Minnow data will appear in the 1998 annual report as the 1997 Age & Growth Analyses. Catch rates are reported as #fish/100m for benthic trawl (BT) and drifting trammel net (DTN), #fish/180 degree haul for a bag seine (BS), #fish/hr for a statinary gill net (SGN), and #fish/min for electrofishing (EF). See Appendix A for list of macrohabitat acronyms.

Hybognathus spp.

Western Silvery Minnow, Plains Minnow, Brassy Minnow



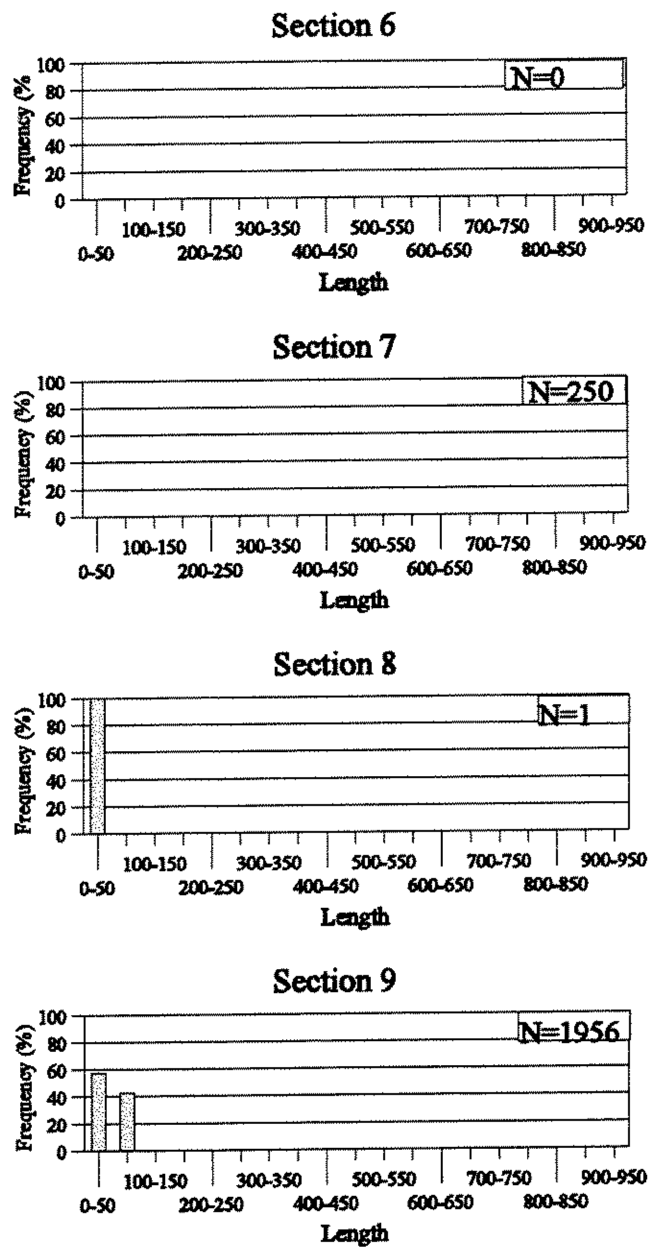


Figure 54. Length-frequency histograms of *Hybognathus spp.* collected from Missouri and Yellowstone River sections using drifting trammel nets, experimental gill nets, benthic trawls, bag seines, and boat electrofishing. Remaining data will appear in 1997 Age & Growth Analyses. See Table 1 for section definitons.

Hybognathus spp.

Western Silvery Minnow, Plains Minnow, Brassy Minnow

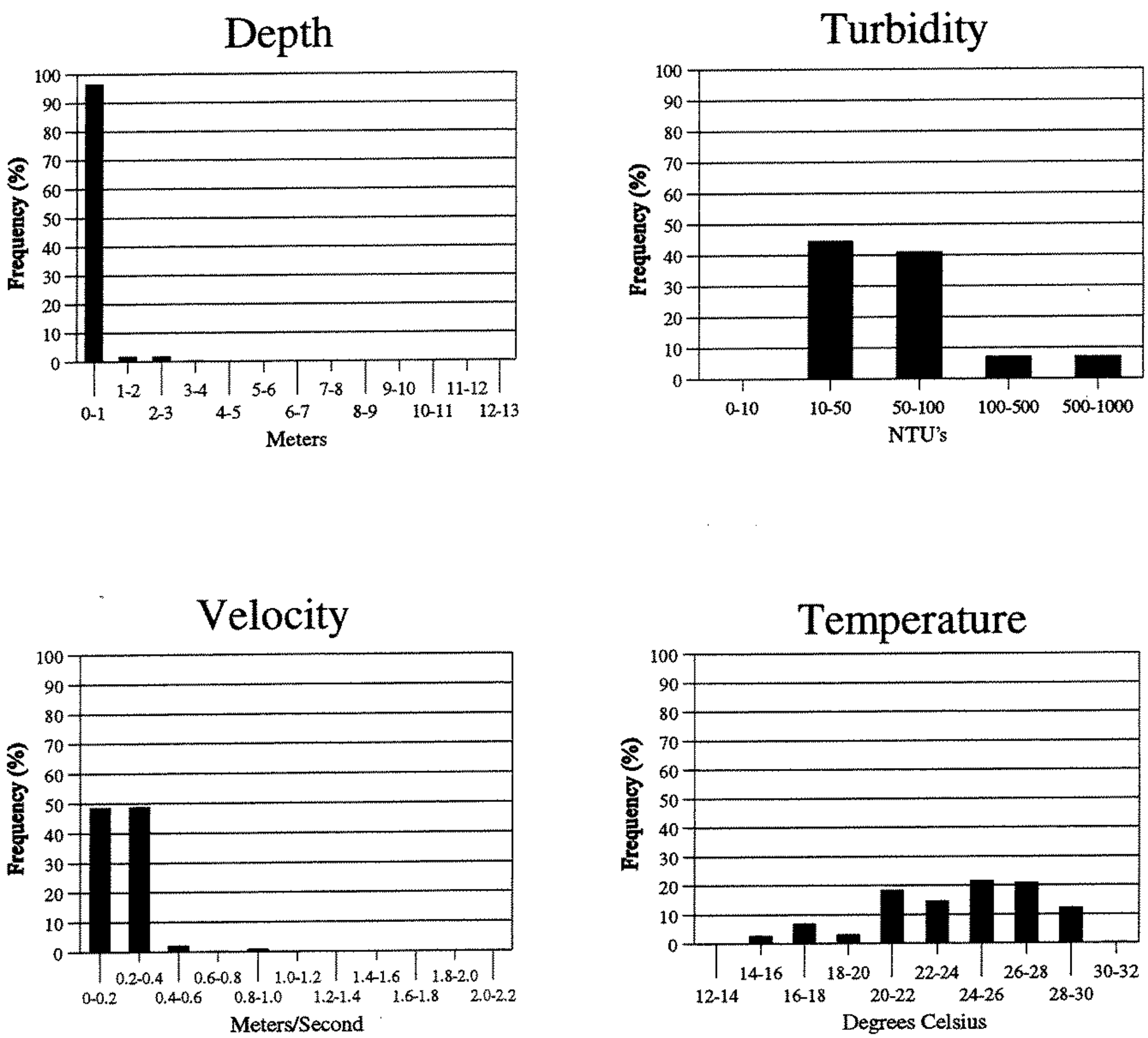


Figure 55. Frequency of occurrence of *Hybognathus spp.* (N=4158) in various depth, velocity, turbidity, and water temperature intervals from Missouri and Yellowstone River collections.

Pallid sturgeon (PDSG)

One pallid sturgeon was caught in 1997. It was captured in Segment 10 (between the Yellowstone River confluence and Lake Sakakawea) in a large tributary mouth (TRM-LRGE) with a drifting trammel net (DTN). Associated physical habitat variables were depth: 4.8 m, velocity: 0.85 m/s, conductivity: 444 μS/cm, turbidity: 268 NTU's, temperature: 19.5°C, and substrate: 100% sand.

River carpsucker (RVCS)

A total of 3,299 river carpsuckers was captured in all segments with all gears and in all macrohabitats except CHXO (Figure 56). They were frequently captured with the bag seine in SCCs, ISBs, and SCNs (Table 23). About 4% of river carpsuckers were captured in least impacted segments, with 9% and 87% captured in inter-reservoir and channelized segments, respectively.

Most river carpsuckers were captured in shallow water (90% in depths from 0-1 m) and low velocities (97% in velocities < 0.4 m/s) (Figure 58). Most were found in moderate turbidities (89% in turbidities of 10-100 NTUs) and warm waters (69% in temperatures between 24 and 32°C). Less than 5% of all fish were collected in velocities greater than 0.4 m/s and turbidities less than 10 NTUs.

River carpsuckers were captured in all study sections in 1997. Catches in sections 3 and 7 were dominated by fish less than 50 mm (Figure 57). Sections 2, 3, 4, and 8 had fish ranging from 0 to 550 mm in length. Sections 1 and 5 were missing the smallest length classes of fish (0-50 mm and 50-100 mm) and had fish ranging from 300 to 550 mm and 400 to 600 mm in length, respectively.

River Carpsucker

Table 23. Catch-Per-Unit-Effort (CPUE) for river carpsucker by gear, across macrohabitats (CHXO=Channel Cross-Over, ISB=Inside Bend, OSB=Outside Bend, SCC=Secondary Channel Connected, SCN=Secondary Channel Non-Connected, and TRM=Tributary Mouth). Catch rates are reported as #fish/100m for benthic trawl (BT) and drifting trammel net (DTN), #fish/180 degree haul for a bag seine (BS), #fish/hr for a stationary gill net (SGN), and #fish/min for electrofishing (EF). Least-impacted segment numbers = standard font. Inter-reservoir segment numbers = bold font. Channelized segment numbers = italic font. A "-" indicates that no sample was taken.

Segment	CHXO		ISB					OSB			SCC				SCN			TRM			
	BT	DTN	BS	BT	DTN	EF	SGN	BT	DTN	EF	BS	BT	DTN	EF	BS	EF	SGN	BT	DTN	EF	SGN
3	-	0.00	-	-	0.00	0.07	-	-	0.00	0.06	-	-	0.00	0.05	-	-	0.00	-	-	-	-
5	0.00	0.13	-	0.00	0.03	0.07	-	0.00	0.00	0.01	-	0.00	0.00	0.02	-	0.00	0.02	-	-	-	-
7	0.00	0.00	0.33	0.00	0.04	-	-	0.00	0.00	-	0.17	0.00	0.00	-	0.00	-	0.00	-	-	-	0.00
8	0.00	0.00	0.22	0.00	0.00	-	-	0.00	0.00	-	0.33	0.00	0.00	-	0.11	-	-	-	-	-	-
9	0.00	0.00	1.30	0.00	0.00	-	-	0.00	0.04	-	0.72	0.00	0.00	-	3.06	-	-	-	-	-	-
10	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00	0.00	0.47	0.00	0.00	0.00	-	0.31	0.00	0.00	0.00	0.10	-
12	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00	0.01	0.13	-	-	-	0.00	0.09	0.00	-	-	0.00	0.00
14	0.00	0.00	-	0.00	0.00	0.11	-	0.00	0.00	0.03	0.00	0.00	0.00	0.10	0.00	0.15	0.19	-	-	0.10	0.08
15	0.00	0.00	0.07	0.00	0.00	-	0.00	0.00	0.00	0.24	0.07	0.00	0.00	0.06	-	0.56	0.08	-	-	0.61	0.10
17	0.00	0.00	0.33	0.00	0.00	0.05	0.00	0.00	0.00	0.00	-	-	-	-	-	-	-	-	-	0.13	0.04
19	0.00	0.00	-	-	-	0.00	0.00	0.00	0.00	0.00	222	0.00	-	0.00	-	-	-	-	0.00	0.16	0.14
22	0.00	0.00	-	0.04	0.00	0.05	0.00	0.00	0.00	0.01	-	-	-	-	3.00	1.80	0.06	0.10	0.00	0.53	0.10
23	0.00	0.00	0.00	0.00	0.00	0.03	0.01	0.00	0.00	0.02	2.42	0.00	0.00	0.04	-	-	-	0.00	0.00	0.19	0.08
25	0.00	0.00	35.8	0.00	0.00	0.01	0.01	0.00	0.00	0.02	26.3	0.00	0.00	0.09	-	-	-	0.00	0.00	0.10	0.10
27	0.00	0.00	5.27	0.00	0.00	0.01	0.01	0.00	0.00	0.03	9.04	0.08	0.00	0.10	37.1	0.13	0.04	-	-	0.09	0.06

River Carpsucker

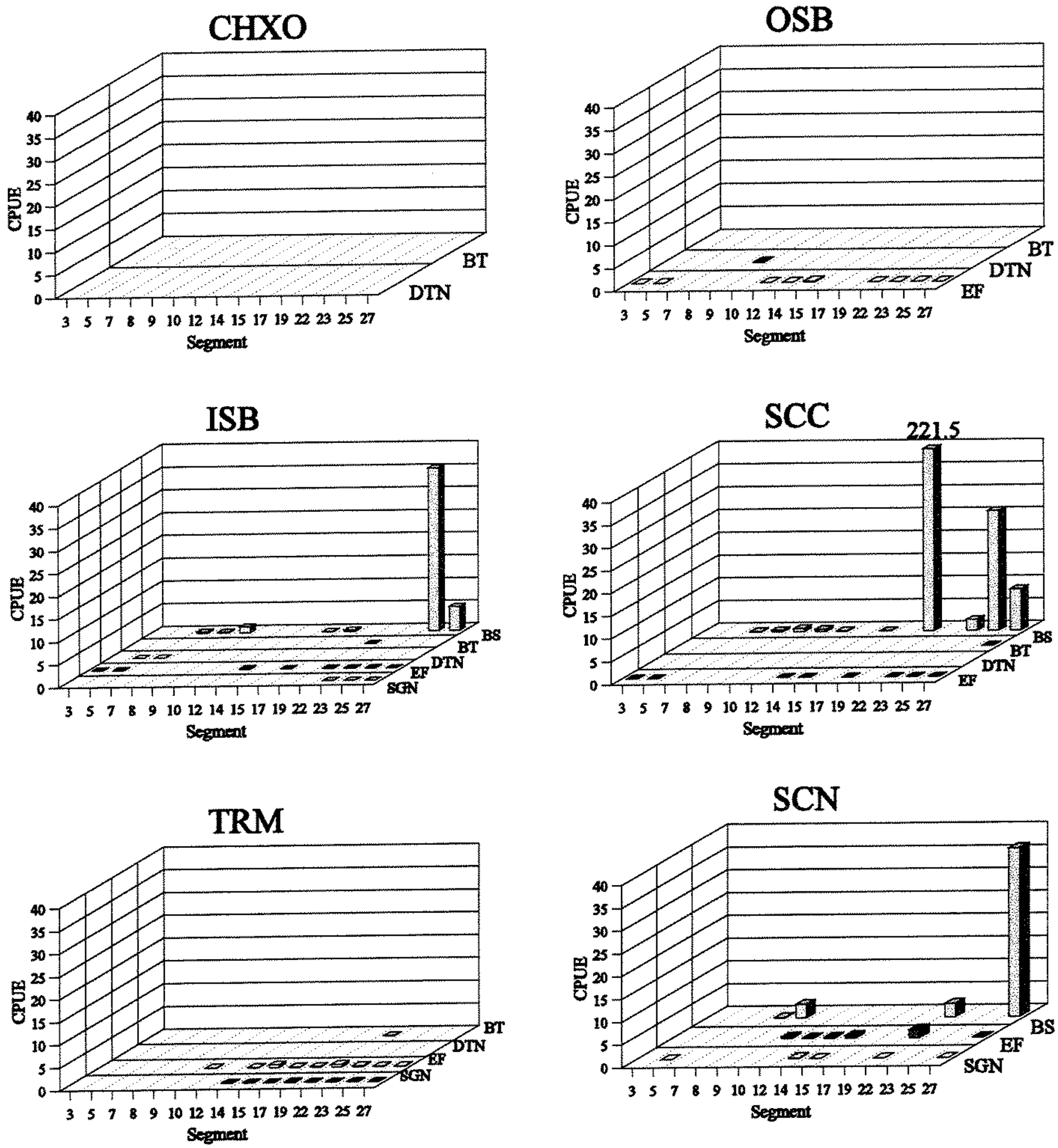
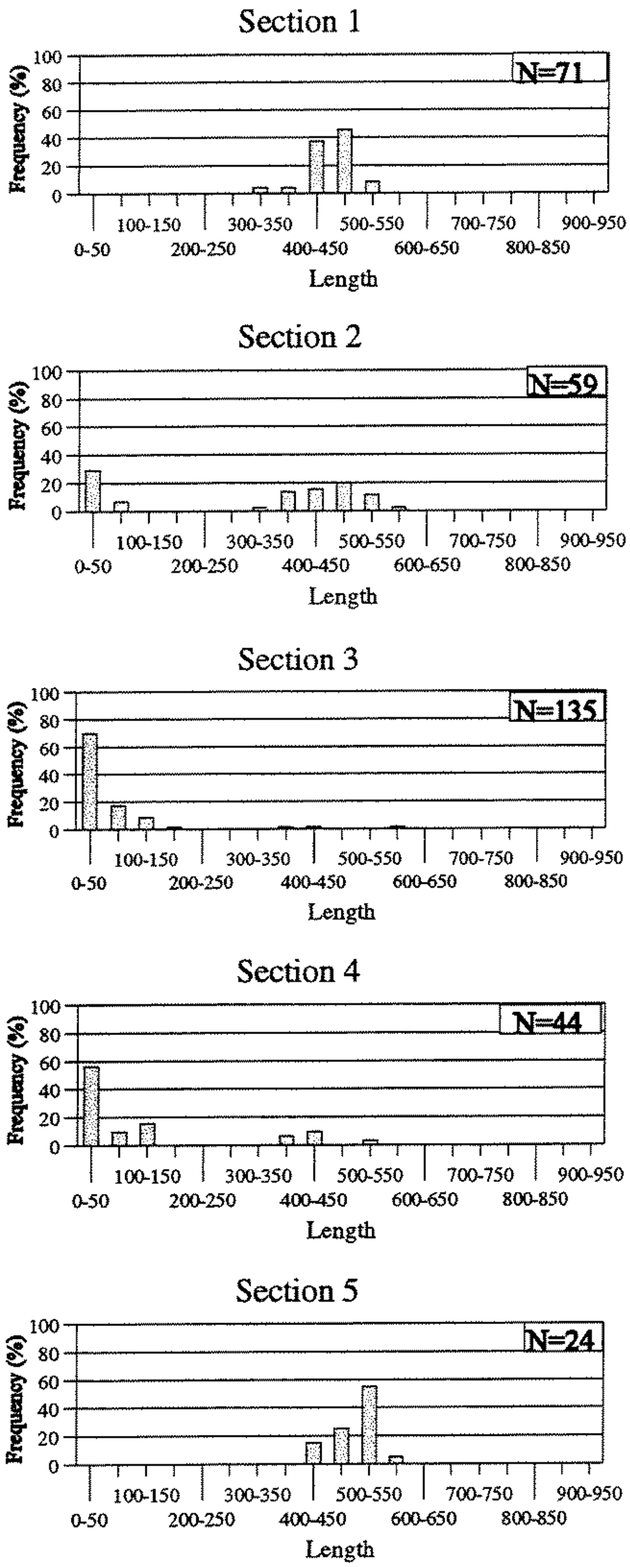


Figure 56. Trends of river carpsucker catch rates among Missouri and Yellowstone River study segments and macrohabitats in 1997. Catch rates are reported as #fish/100m for benthic trawl (BT) and drifting trammel net (DTN), #fish/180 degree haul for a bag seine (BS), #fish/hr for a statinary gill net (SGN), and #fish/min for electrofishing (EF). See Appendix A for list of macrohabitat acronyms.

River Carpsucker



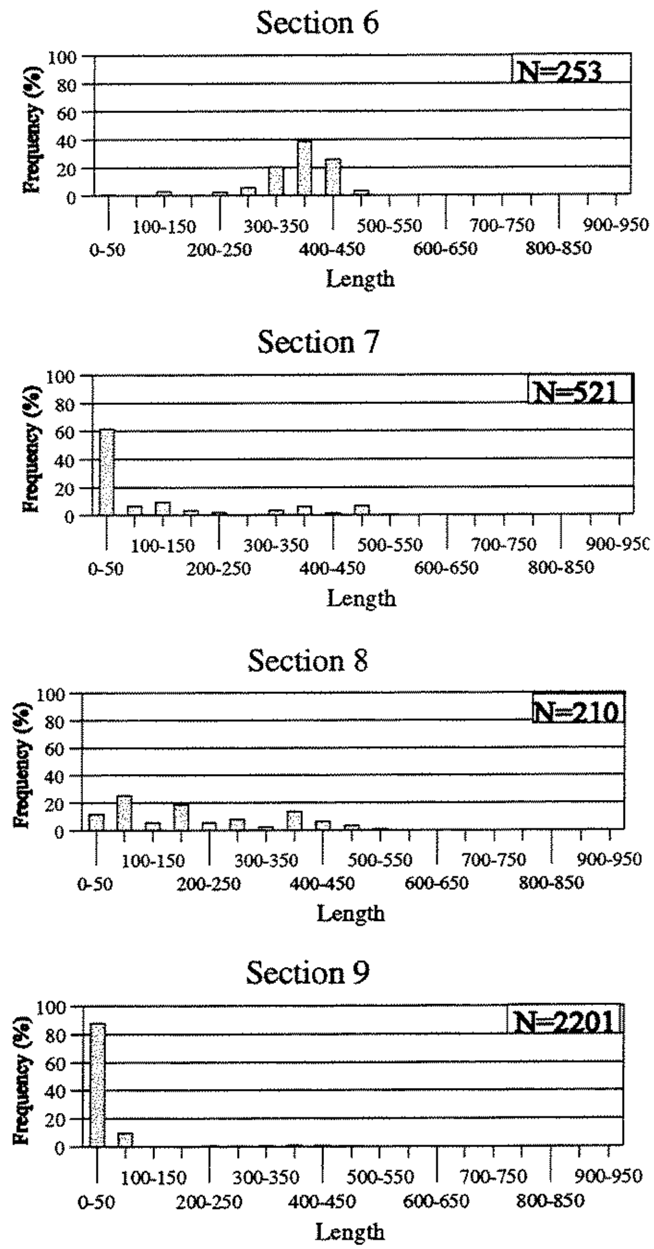


Figure 57. Length-frequency histograms of river carpsucker collected from Missouri and Yellowstone River sections using drifting trammel nets, experimental gill nets, benthic trawls, bag seines, and boat electrofishing. See Table 1 for section definitons.

River Carpsucker

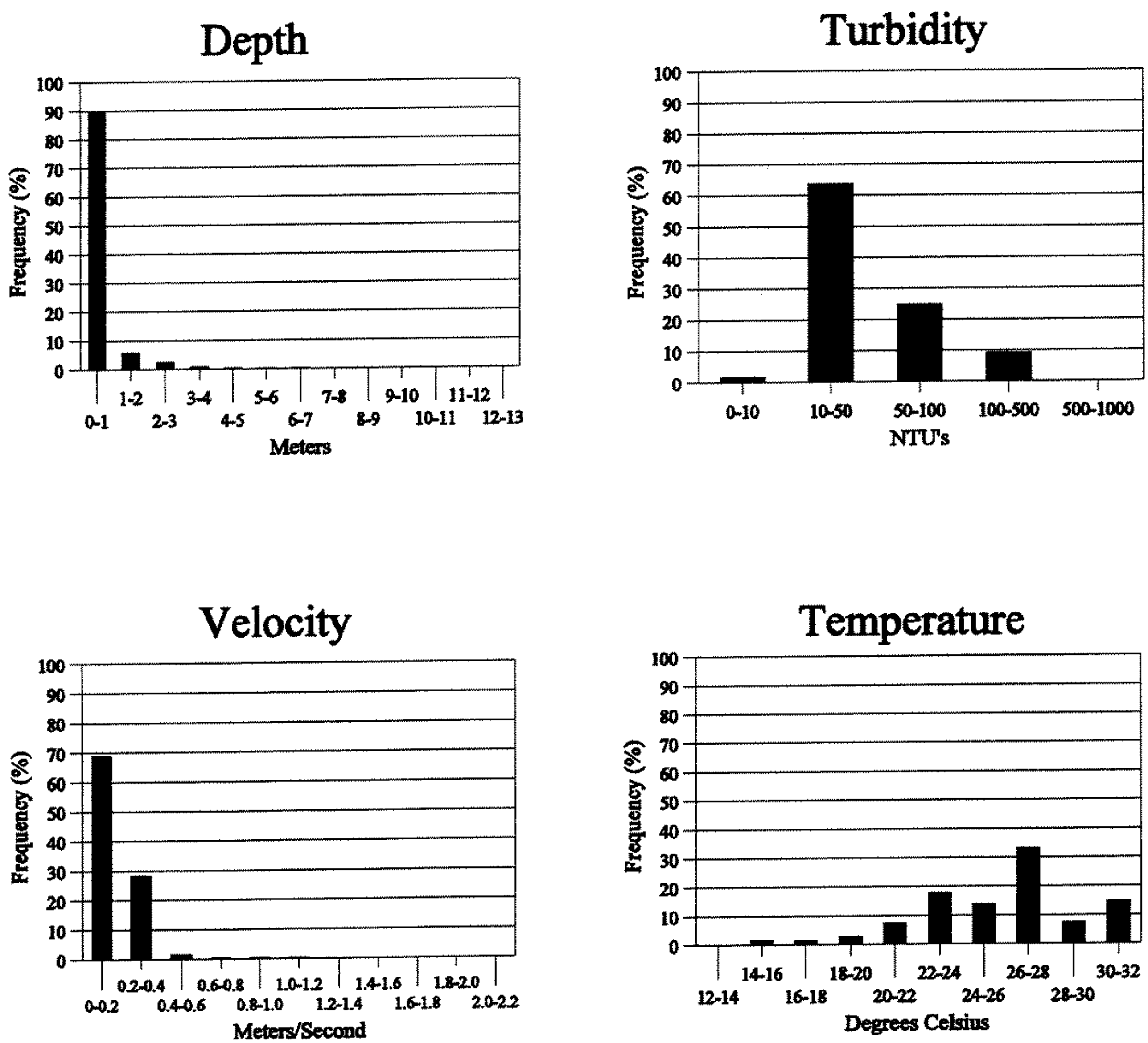


Figure 58. Frequency of occurrence of river carpsucker (N=3299) in various depth, velocity, turbidity, and water temperature intervals from Missouri and Yellowstone River collections.

Sand shiner (SNSN)

The sand shiner was not found upstream from Lake Sakakawea in either year of the study, but was always found at all segments downstream from Garrison Dam (Table 24). The 153 sand shiners collected in 1996 and the 366 collected in 1997 tell the same story of habitat association, population distribution and size structure, and gear vulnerability. Several size classes of this small minnow (<100 mm) were found in each section where the fish was present in 1997 (Figure 60). Seining in inside bends and both types of secondary channels (Figure 59) collected most fish. The habitat associations are narrower than those of some benthic fishes. For example, 75-95% of the sand shiners were captured where water temperatures were from 22-28 °C, where water velocity was <0.4 m/s, where depths were <1 m, and where water transparency was relatively high (Figure 61).

Sand Shiner

Table 24. Catch-Per-Unit-Effort (CPUE) for sand shiner by gear, across macrohabitats (CHXO=Channel Cross-Over, ISB=Inside Bend, OSB=Outside Bend, SCC=Secondary Channel Connected, SCN=Secondary Channel Non-Connected, and TRM=Tributary Mouth). Catch rates are reported as #fish/100m for benthic trawl (BT) and drifting trammel net (DTN), #fish/180 degree haul for a bag seine (BS), #fish/hr for a stationary gill net (SGN), and #fish/min for electrofishing (EF). Least-impacted segment numbers = standard font. Inter-reservoir segment numbers = bold font. Channelized segment numbers = italic font. A "-" indicates that no sample was taken.

Segment	CHXO		ISB					OSB			SCC				SCN			TRM			
	BT	DTN	BS	BT	DTN	EF	SGN	BT	DTN	EF	BS	BT	DTN	EF	BS	EF	SGN	BT	DTN	EF	SGN
3	-	0.00	-	-	0.00	0.00	-	-	0.00	0.00	-	-	0.00	0.00	-	-	0.00	-	-	-	-
5	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.00	-	-	-	-
7	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00	-	0.00	0.00	0.00	-	0.00	-	0.00	-	-	-	0.00
8	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00	-	0.00	0.00	0.00	-	0.00	-	-	-	-	-	-
9	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00	-	0.00	0.00	0.00	-	0.00	-	-	-	-	-	-
10	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	0.00	0.00	0.00	0.00	0.00	-
12	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00	0.00	0.00	-	-	-	0.00	0.00	0.00	-	-	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	0.01	0.00
15	0.00	0.00	1.47	0.00	0.00	-	0.00	0.00	0.00	0.04	8.00	0.00	0.00	0.00	-	0.00	0.00	-	-	0.01	0.00
17	0.00	0.00	2.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	-	-	-	-	-	-	-	0.00	0.00
19	0.00	0.00	-	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	0.00	-	-	-	-	0.00	0.01	0.00
22	0.00	0.00	-	0.00	0.00	0.00	0.00	0.00	0.00	0.02	-	-	-	-	0.00	0.00	0.00	0.00	0.00	0.01	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	-	0.00	0.00	0.00	0.00
25	0.00	0.00	0.13	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.00	-	-	-	0.00	0.00	0.00	0.00
27	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.22	0.13	0.00	0.00	5.07	0.00	0.00	-	-	0.00	0.00

Sand Shiner

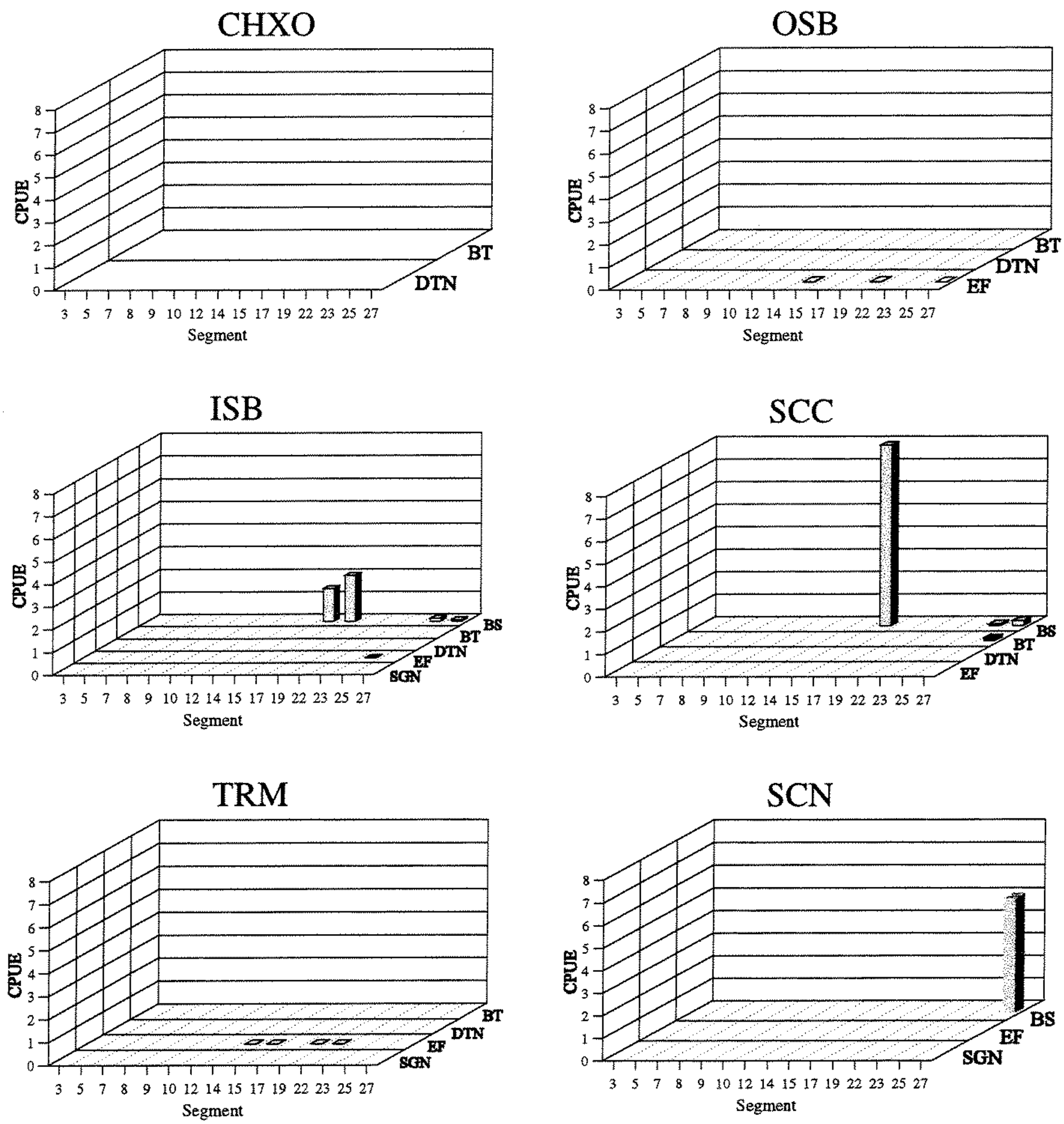


Figure 59. Trends of sand shiner catch rates among Missouri and Yellowstone River study segments and macrohabitats in 1997. Catch rates are reported as #fish/100m for benthic trawl (BT) and drifting trammel net (DTN), #fish/180 degree haul for a bag seine (BS), #fish/hr for a statinary gill net (SGN), and #fish/min for electrofishing (EF). See Appendix A for list of macrohabitat acronyms.

Sand Shiner

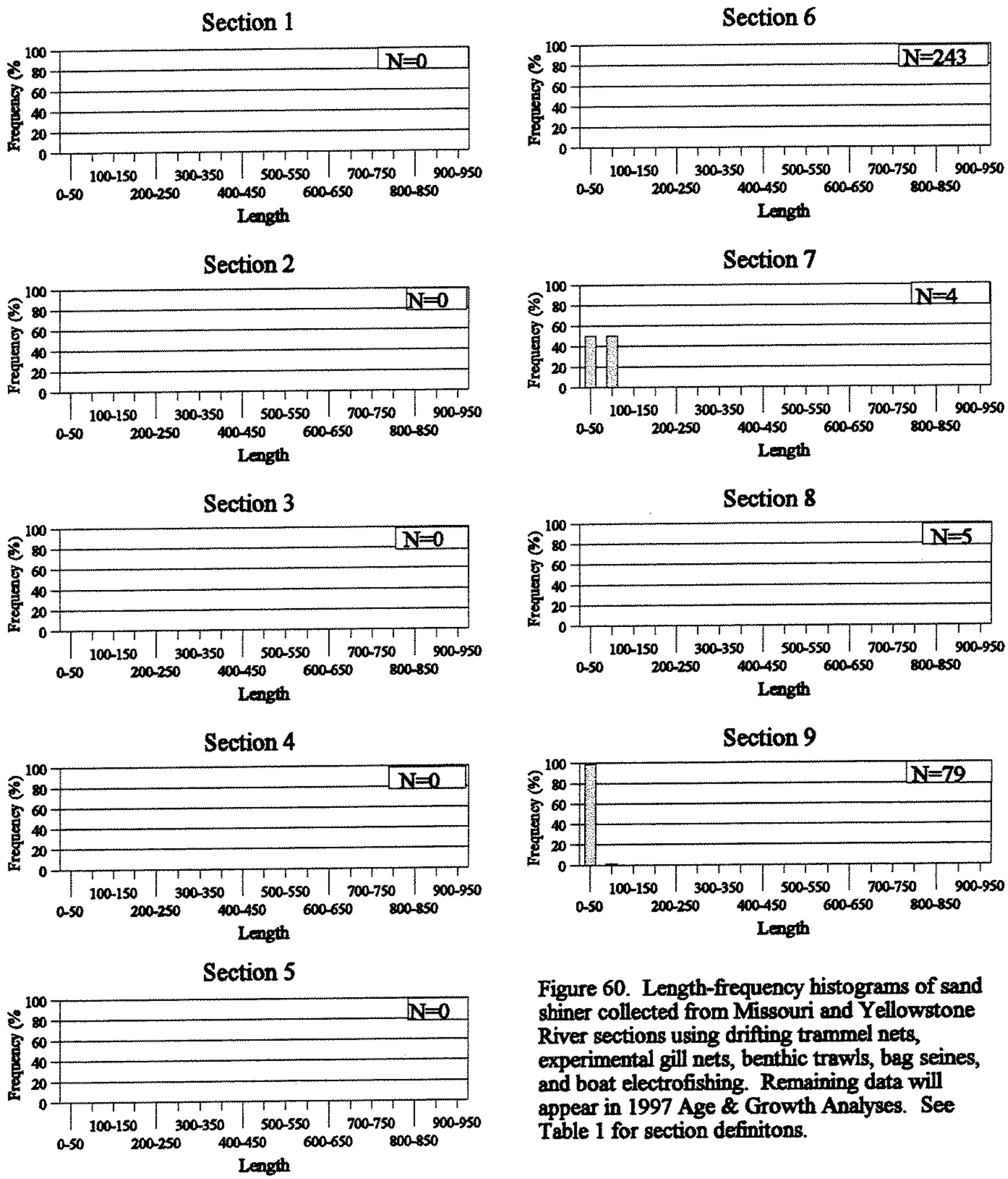


Figure 60. Length-frequency histograms of sand shiner collected from Missouri and Yellowstone River sections using drifting trammel nets, experimental gill nets, benthic trawls, bag seines, and boat electrofishing. Remaining data will appear in 1997 Age & Growth Analyses. See Table 1 for section definitons.

Sand Shiner

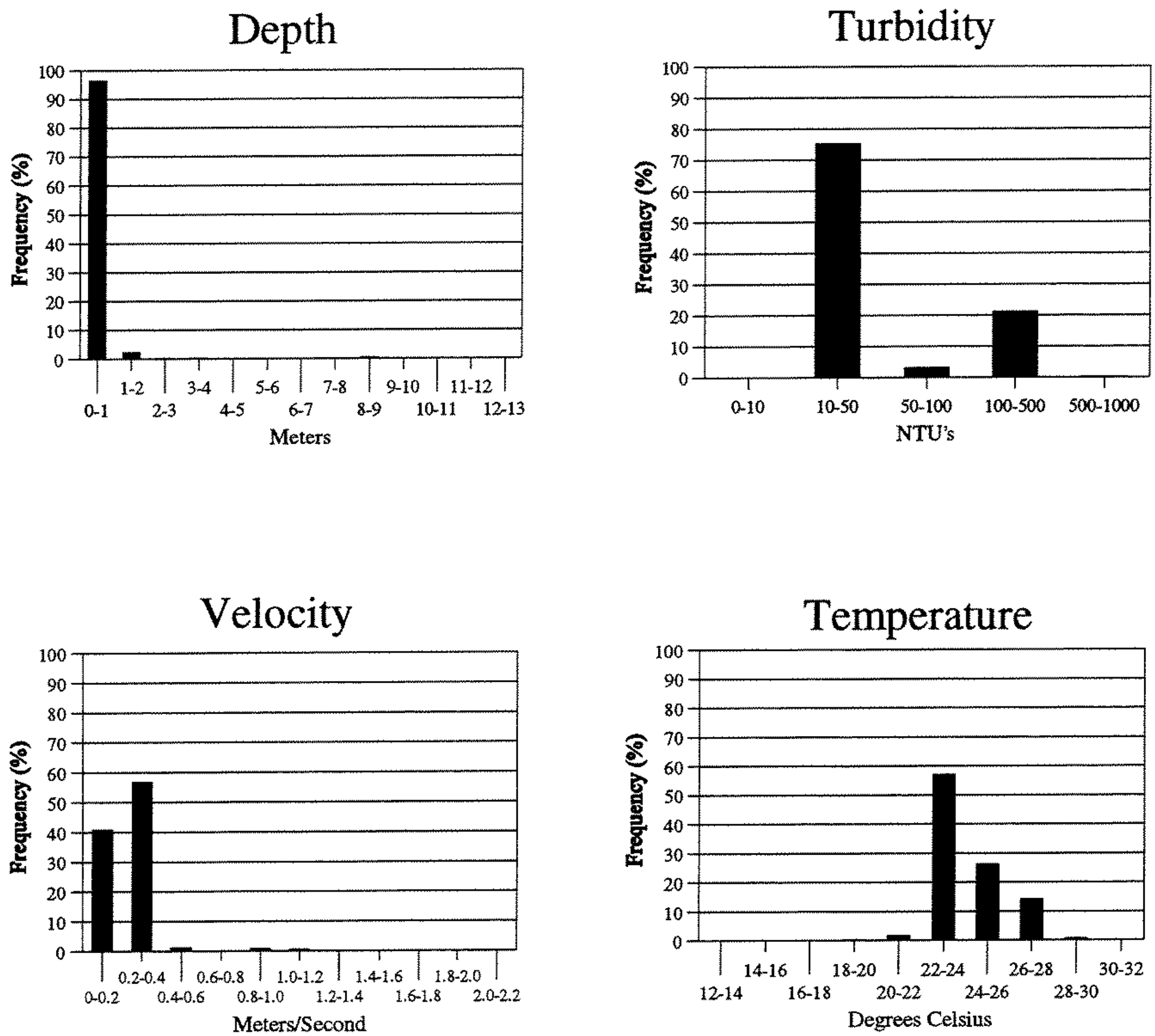


Figure 61. Frequency of occurrence of sand shiner (N=359) in various depth, velocity, turbidity, and water temperature intervals from Missouri and Yellowstone River collections.

Sauger (SGER)

A total of 160 sauger was captured. Fish were caught in each segment, except 27, and each macrohabitat (Figure 62). Highest CPUE's were obtained in segment **15** with the stationary gill net in SCN (0.19/hr) and with the drifting trammel net in OSB (0.17/hour). Overall most fish were captured in SCC, TRM, and ISB (Table 25). Fish were captured with each gear except the benthic trawl.

Most sauger were captured in shallow water (76% in depths < 2 m) exhibiting low turbidities (74% in turbidities < 100 NTUs) and low velocities (75% in velocities < 0.4 m/s) (Figure 64). Sauger were captured at water temperatures ranging from12 to 28°C, however, most fish were captured in water temperatures ranging from 20 to 26°C. Fewer than 5% of all sauger were captured in water depths greater than 4 m, turbidities greater than 500 NTUs, and current velocities greater than 1.0 m/s.

No sauger less than 50 mm and few in the 50-100 mm length category were captured in 1997 (Figure 63) therefore, length-frequency distributions were irregular for most sections. The absence of 0-50 mm fish and the scarcity of 50-100 mm fish suggests that either these fish did not recruit to our gears, or that poor reproduction occurred in most sections of the river in 1997.

Sauger

Table 25. Catch-Per-Unit-Effort (CPUE) for sauger by gear, across macrohabitats (CHXO=Channel Cross-Over, ISB=Inside Bend, OSB=Outside Bend, SCC=Secondary Channel Connected, SCN=Secondary Channel Non-Connected, and TRM=Tributary Mouth). Catch rates are reported as #fish/100m for benthic trawl (BT) and drifting trammel net (DTN), #fish/180 degree haul for a bag seine (BS), #fish/hr for a stationary gill net (SGN), and #fish/min for electrofishing (EF). Least-impacted segment numbers = standard font. Inter-reservoir segment numbers = bold font. Channelized segment numbers = italic font. A "-" indicates that no sample was taken.

Segment	CHXO		ISB					OSB			SCC				SCN			TRM			
	BT	DTN	BS	BT	DTN	EF	SGN	BT	DTN	EF	BS	BT	DTN	EF	BS	EF	SGN	BT	DTN	EF	SGN
3	-	0.00	-	-	0.00	0.03	-	-	0.00	0.09	-	-	0.00	0.05	-	-	0.00	-	-	-	-
5	0.00	0.03	-	0.00	0.03	0.07	-	0.00	0.00	0.09	-	0.00	0.09	0.04	-	0.00	0.00	-	-	-	-
7	0.00	0.00	0.00	0.00	0.02	-	-	0.00	0.00	-	0.00	0.00	0.02	-	0.00	-	0.00	-	-	-	0.00
8	0.00	0.00	0.00	0.00	0.04	-	-	0.00	0.00	-	0.09	0.00	0.00	-	0.00	-	-	-	-	-	-
9	0.00	0.02	0.00	0.00	0.02	-	-	0.00	0.04	-	0.06	0.00	0.07	-	0.00	-	-	-	-	-	-
10	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00	0.17	0.00	0.00	0.00	0.05	-	0.00	0.00	0.00	0.00	0.00	-
12	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00	0.00	0.00	-	-	-	0.00	0.03	0.00	-	-	0.05	0.00
14	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.19	-	-	0.04	0.01
15	0.00	0.00	0.00	0.00	0.00	-	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.01	-	0.00	0.00	-	-	0.01	0.03
17	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	-	-	-	-	-	-	-	-	-	0.02	0.06
19	0.00	0.00	-	-	-	0.02	0.00	0.00	0.00	0.00	0.50	0.00	-	0.03	-	-	-	-	0.00	0.02	0.05
22	0.00	0.00	-	0.00	0.00	0.02	0.00	0.00	0.00	0.02	-	-	-	-	0.00	0.03	0.04	0.00	0.00	0.04	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	-	-	-	0.00	0.00	0.02	0.03
25	0.00	0.00	0.07	0.00	0.00	0.02	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	-	-	-	0.00	0.00	0.04	0.00
27	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	-	-	0.02	0.00

Sauger

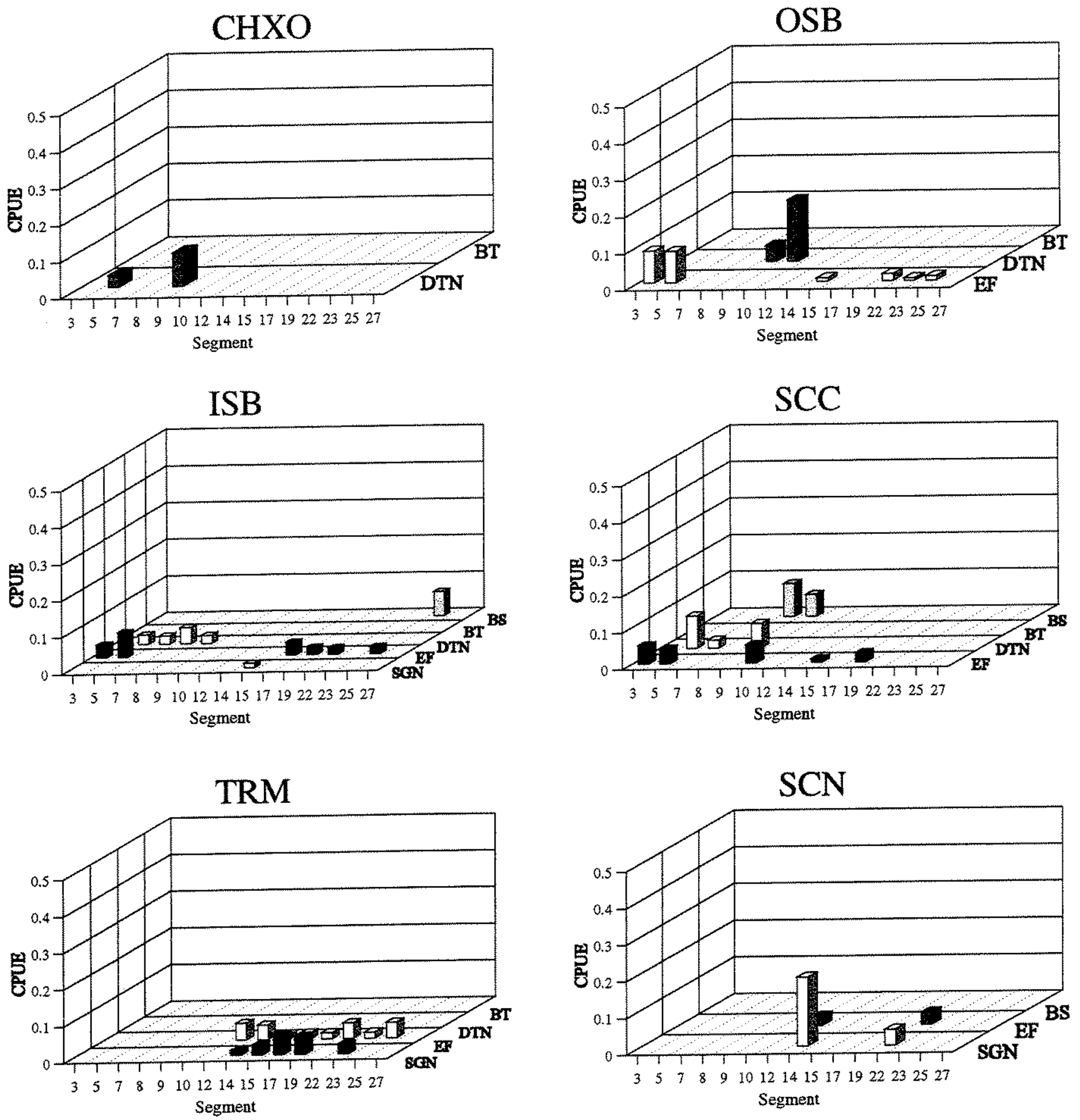
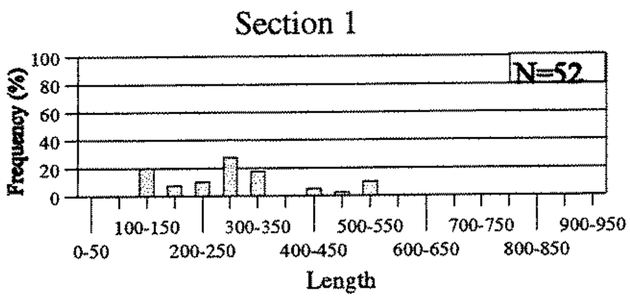
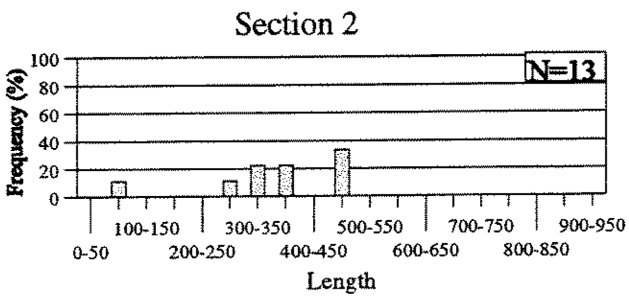
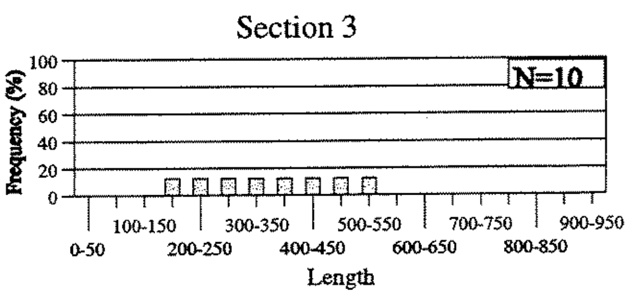


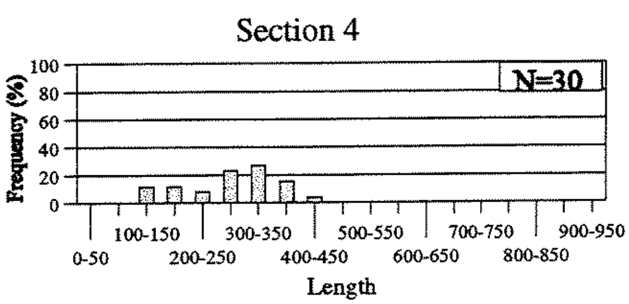
Figure 62. Trends of sauger catch rates among Missouri and Yellowstone River study segments and macrohabitats in 1997. Catch rates are reported as #fish/100m for benthic trawl (BT) and drifting trammel net (DTN), #fish/180 degree haul for a bag seine (BS), #fish/hr for a statinary gill net (SGN), and #fish/min for electrofishing (EF). See Appendix A for list of macrohabitat acronyms.

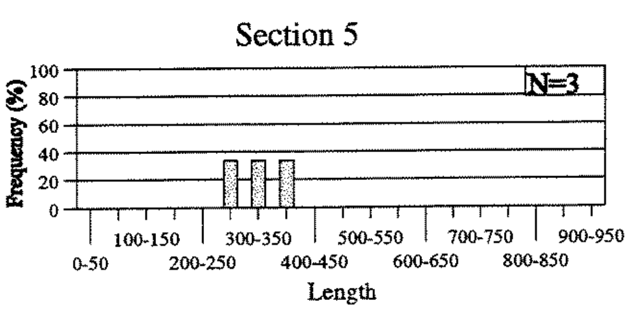
Sauger

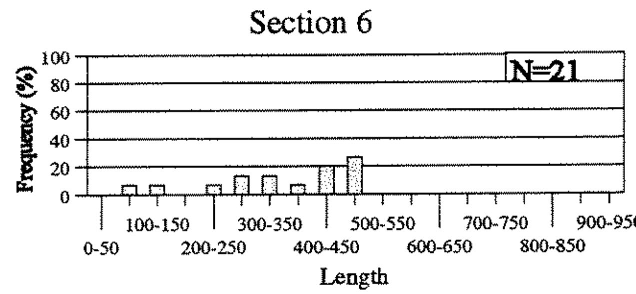


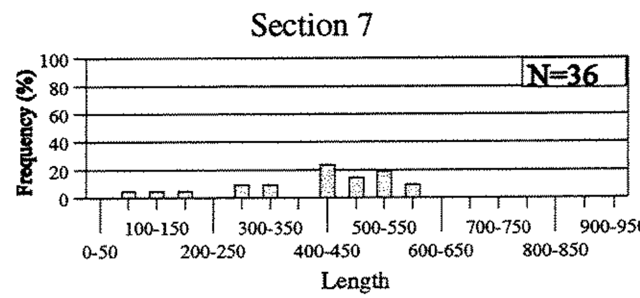


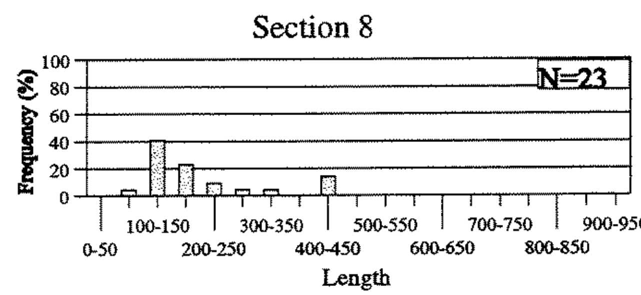












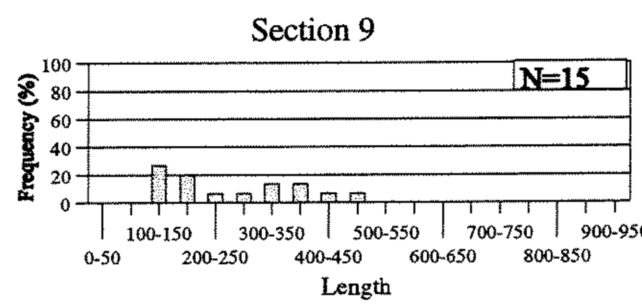


Figure 63. Length-frequency histograms of sauger collected from Missouri and Yellowstone River sections using drifting trammel nets, experimental gill nets, benthic trawls, bag seines, and boat electrofishing. See Table 1 for section definitons.

Sauger

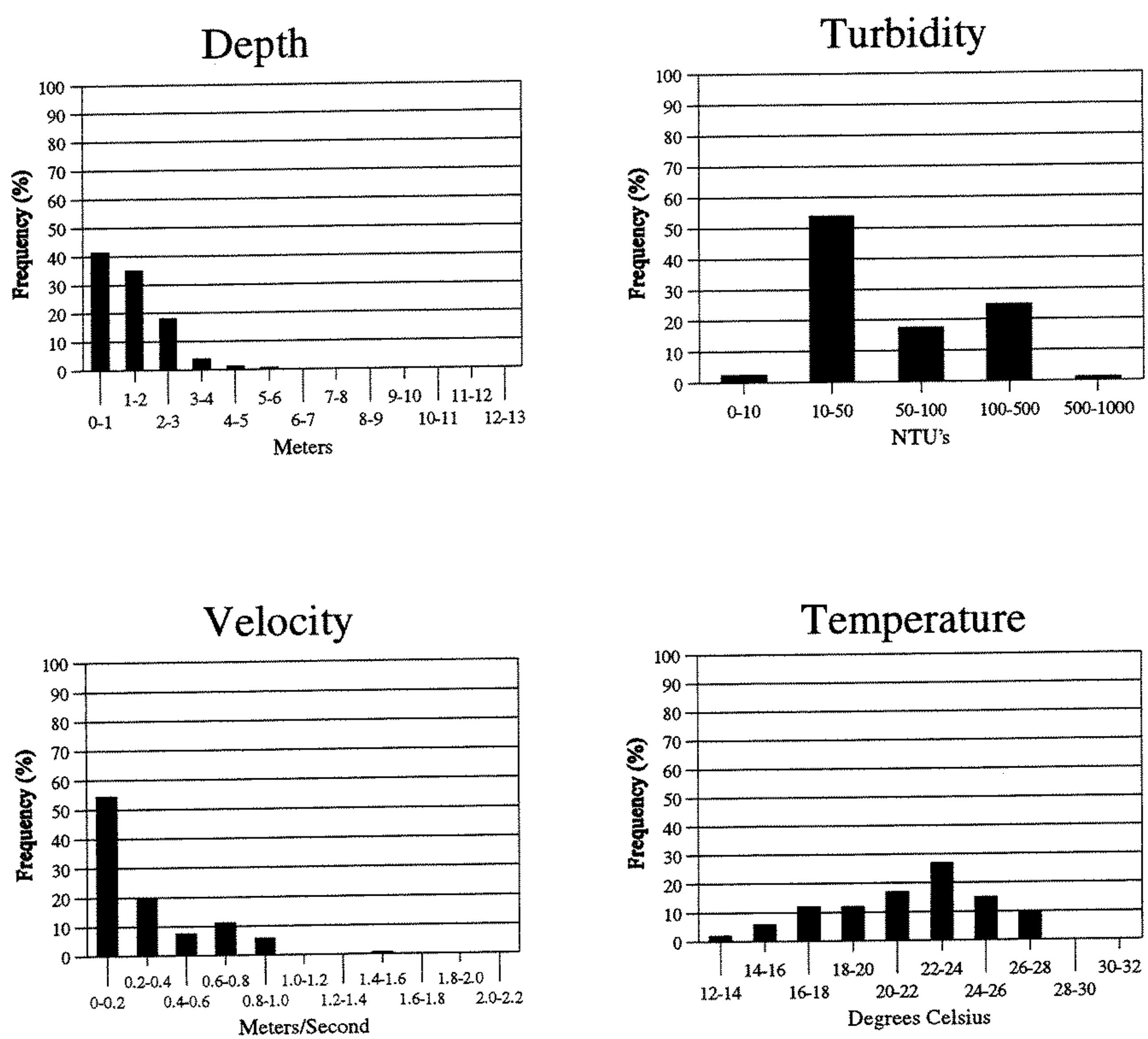


Figure 64. Frequency of occurrence of sauger (N=160) in various depth, velocity, turbidity, and water temperature intervals from Missouri and Yellowstone River collections.

Shorthead redhorse (SHRH)

A total of 321 shorthead redhorse was captured in 1997. Individuals were captured in each macrohabitat and in each segment, except in channelized segments *19*, *22*, and *23* (Figure 65). Shorthead redhorse were captured with all gears. Highest CPUE's occurred in segments **15** with the bag seine in ISB (1.47/haul) and in segment 3 with the drifting trammel net in SCC (1.11/100m) (Table 26). Most shorthead redhorse were captured in least-impacted and inter-reservoir segments.

Most shorthead redhorse were captured in shallow water (75% in depths < 2m) exhibiting low turbidities (72% in turbidities < 50 NTUs) (Figure 67). Although fish were captured in a wide range of current velocities (0.0-2.0 m/s) and temperatures (12-30°C), few were captured in depths greater than 4 m and velocities greater than 1.0 m/s.

Shorthead redhorse were captured in each study section in 1997. However, all length categories from 0-550 mm were represented in sections 1 and 6 where the majority of fish were captured (Figure 66). For example, section 1 had fish ranging from 0 to 550 mm in length, whereas samples in section 8 yielded fish of two length categories (100-150 and 400-450 mm).

Shorthead Redhorse

Table 26. Catch-Per-Unit-Effort (CPUE) for shorthead redhorse by gear, across macrohabitats (CHXO=Channel Cross-Over, ISB=Inside Bend, OSB=Outside Bend, SCC=Secondary Channel Connected, SCN=Secondary Channel Non-Connected, and TRM=Tributary Mouth). Catch rates are reported as #fish/100m for benthic trawl (BT) and drifting trammel net (DTN), #fish/180 degree haul for a bag seine (BS), #fish/hr for a stationary gill net (SGN), and #fish/min for electrofishing (EF). Least-impacted segment numbers = standard font. Inter-reservoir segment numbers = bold font. Channelized segment numbers = italic font. A "-" indicates that no sample was taken.

Segment	CHXO		ISB					OSB			SCC				SCN			TRM			
	BT	DTN	BS	BT	DTN	EF	SGN	BT	DTN	EF	BS	BT	DTN	EF	BS	EF	SGN	BT	DTN	EF	SGN
3	-	0.07	-	-	0.00	0.17	-	-	0.04	0.46	-	-	1.11	0.05	-	-	0.00	-	-	-	-
5	0.00	0.02	-	0.00	0.00	0.28	-	0.00	0.00	0.14	-	0.04	0.37	0.02	-	0.00	0.00	-	-	-	-
7	0.00	0.00	0.00	0.00	0.00	-	-	0.02	0.08	-	0.06	0.00	0.09	-	0.00	-	0.00	-	-	-	0.00
8	0.00	0.04	0.11	0.00	0.00	-	-	0.09	0.04	-	0.15	0.00	0.08	-	0.67	-	-	-	-	-	-
9	0.00	0.00	0.00	0.13	0.00	-	-	0.00	0.07	-	0.06	0.00	0.04	-	0.28	-	-	-	-	-	-
10	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.05	-	0.01	0.00	0.00	0.00	0.00	-
12	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00	0.01	0.00	-	-	-	0.17	0.00	0.00	-	-	0.03	0.00
14	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	-	-	0.00	0.00
15	0.00	0.04	1.47	0.00	0.00	-	0.01	0.00	0.00	0.26	0.46	0.00	0.00	0.16	-	0.16	0.04	-	-	0.06	0.04
17	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.03	-	-	-	-	-	-	-	-	-	0.01	0.03
19	0.00	0.00	-	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	0.00	-	-	-	-	0.00	0.00	0.00
22	0.00	0.00	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	-	0.00	0.00	0.04	0.00
25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	-	-	-	0.00	0.00	0.01	0.01
27	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	-	-	0.00	0.02

Shorthead Redhorse

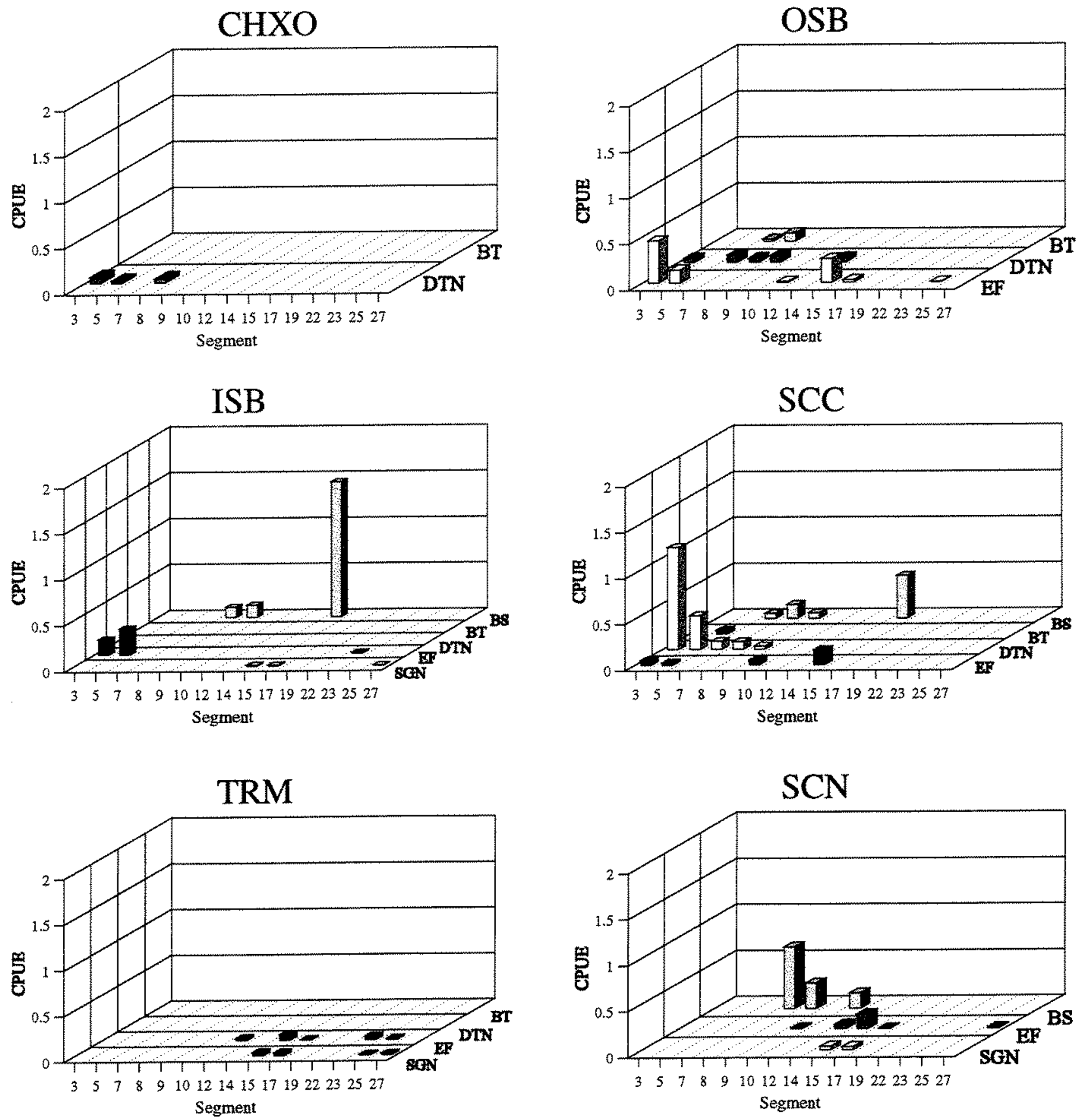


Figure 65. Trends of shorthead redhorse catch rates among Missouri and Yellowstone River study segments and macrohabitats in 1997. Catch rates are reported as #fish/100m for benthic trawl (BT) and drifting trammel net (DTN), #fish/180 degree haul for a bag seine (BS), #fish/hr for a statinary gill net (SGN), and #fish/min for electrofishing (EF). See Appendix A for list of macrohabitat acronyms.

Shorthead Redhorse

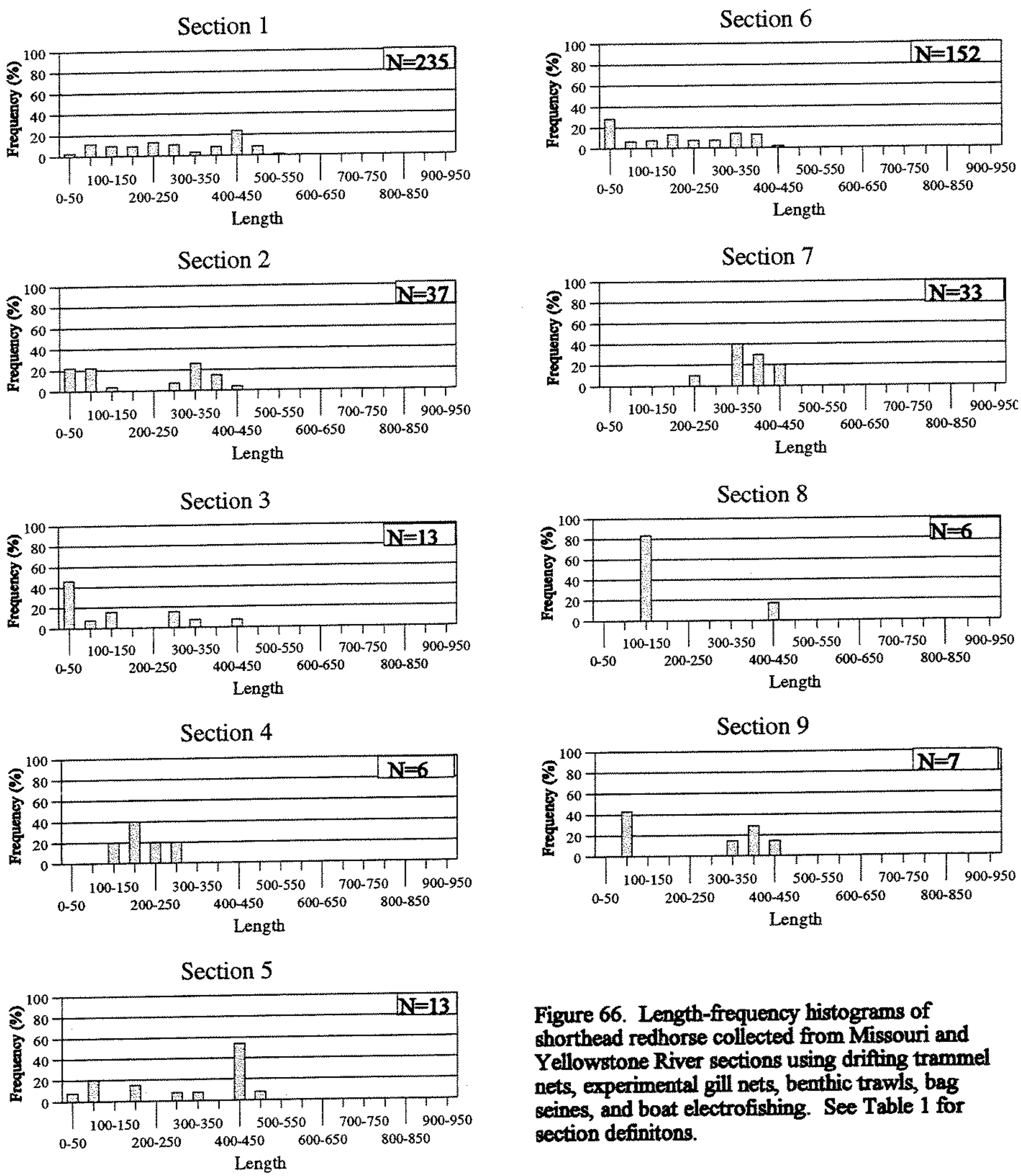


Figure 66. Length-frequency histograms of shorthead redhorse collected from Missouri and Yellowstone River sections using drifting trammel nets, experimental gill nets, benthic trawls, bag seines, and boat electrofishing. See Table 1 for section definitons.

Shorthead Redhorse

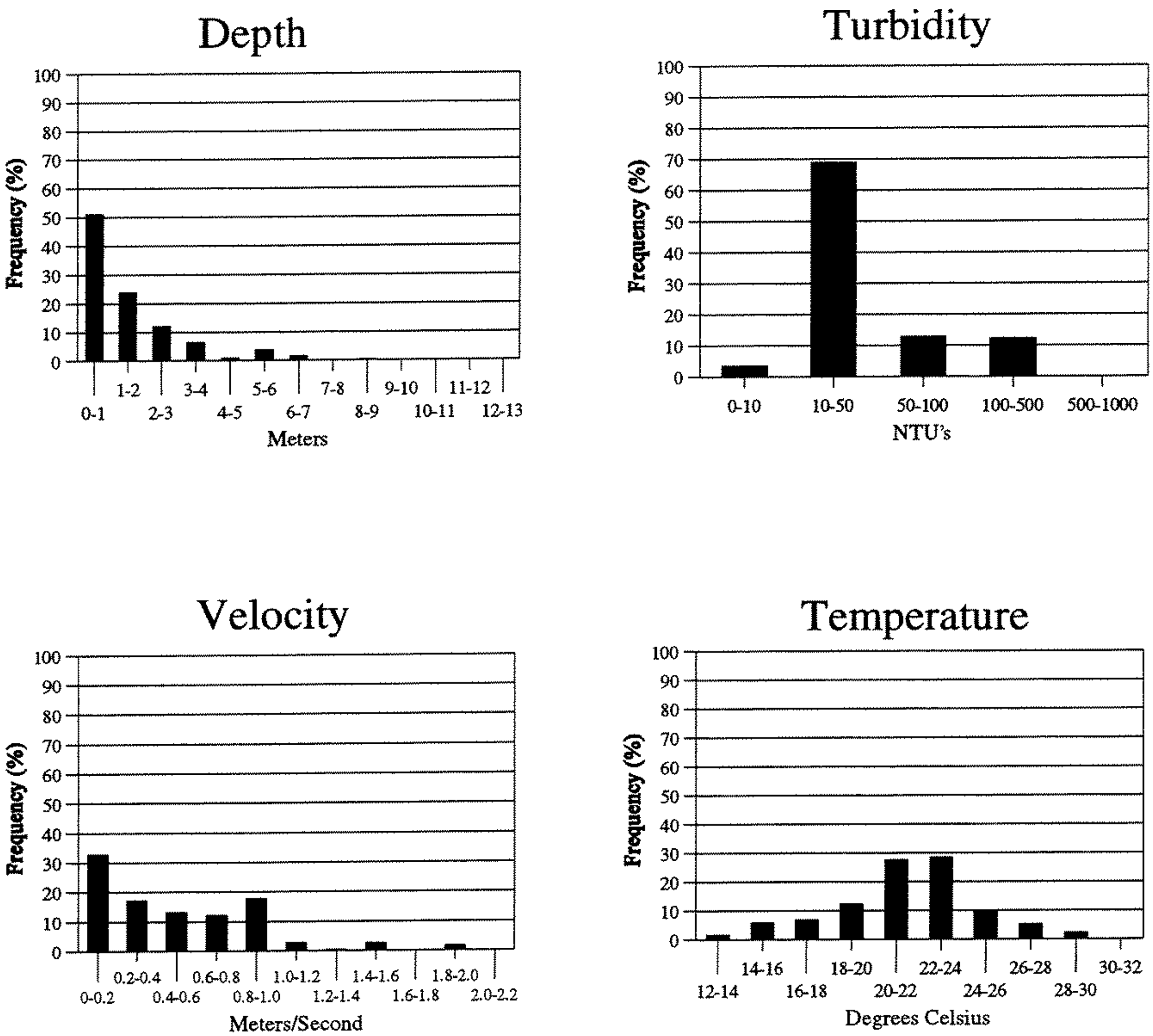


Figure 67. Frequency of occurrence of shorthead redhorse (N=321) in various depth, velocity, turbidity, and water temperature intervals from Missouri and Yellowstone River collections.

Shovelnose sturgeon (SNSG)

The catch of shovelnose sturgeon approximately doubled between 1996 (n = 245) and 1997 (n = 565). As in the previous year, fish appeared in all segments at about the same abundance. The lowest catches were recorded between lakes Sakakawea and Oahe (Segment 12), between lakes Lewis and Clark and Francis Case (Segment 14), and immediately downstream from Gavins Point Dam (Table 27). This species grows to about 1,000 mm in length with the larger specimens always captured in the upper river (Figure 69). However, it is only in the lower river (Sections 8 and 9) where the smallest size classes are regularly found. Sturgeons are found at a wide range of depths, turbidity levels, velocities, and temperatures, without a marked association with any particular water quality characteristic (Figure 70). The species was vulnerable to all gears, but trawling and drifted trammel nets were most effective (Figure 68). Most sturgeon were captured in main river habitats (inside and outside bends, channel cross overs, secondary channel connected). The data are very similar to that collected in 1996, even the suggestion that sturgeon change from inhabiting outside bends and channel cross overs in the upper river to inside bends in the lower river (Figure 68).

Shovelnose Sturgeon

Table 27. Catch-Per-Unit-Effort (CPUE) for shovelnose sturgeon by gear, across macrohabitats (CHXO=Channel Cross-Over, ISB=Inside Bend, OSB=Outside Bend, SCC=Secondary Channel Connected, SCN=Secondary Channel Non-Connected, and TRM=Tributary Mouth). Catch rates are reported as #fish/100m for benthic trawl (BT) and drifting trammel net (DTN), #fish/180 degree haul for a bag seine (BS), #fish/hr for a stationary gill net (SGN), and #fish/min for electrofishing (EF). Least-impacted segment numbers = standard font. Inter-reservoir segment numbers = bold font. Channelized segment numbers = italic font. A "-" indicates that no sample was taken.

Segment	CHXO		ISB					OSB			SCC				SCN			TRM			
	BT	DTN	BS	BT	DTN	EF	SGN	BT	DTN	EF	BS	BT	DTN	EF	BS	EF	SGN	BT	DTN	EF	SGN
3	-	0.07	-	-	0.02	0.00	-	-	0.27	0.00	-	-	0.00	0.00	-	-	0.00	-	-	-	-
5	0.00	0.52	-	0.03	0.24	0.00	-	0.08	0.60	0.01	-	0.00	0.18	0.00	-	0.00	0.00	-	-	-	-
7	0.00	0.16	0.00	0.03	0.20	-	-	0.02	0.26	-	0.00	0.00	0.33	0.00	0.00	-	0.00	-	-	-	
8	0.00	0.02	0.00	0.00	0.07	-	-	0.04	0.04	-	0.03	0.00	0.31	0.00	0.00	-	-	-	-	-	-
9	0.00	0.54	0.00	0.03	0.85	-	-	0.00	0.37	-	0.00	0.02	0.40	0.00	0.00	-	-	-	-	-	-
10	0.00	0.04	0.00	0.00	0.07	-	-	0.05	0.17	0.00	0.00	0.00	0.00	0.00	-	0.00	0.00	0.00	0.44	0.00	-
12	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.06	0.00	0.00	-	-	0.00	0.00	0.00	0.00	-	-	0.00	0.00
14	0.00	0.00	-	0.00	0.04	0.00	-	0.00	0.05	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.00	-	-	0.00	0.00
15	0.00	0.03	0.07	0.05	0.00	-	0.02	0.02	0.04	0.00	0.00	0.00	0.09	0.00	-	0.00	0.00	-	-	0.00	0.03
17	0.00	0.00	0.00	0.00	0.17	0.00	0.27	0.00	0.07	0.00	-	-	-	-	-	-	-	-	-	0.00	0.08
19	0.00	0.00	-	-	-	0.00	0.02	0.00	0.00	0.00	0.00	0.00	-	0.04	-	-	-	-	0.00	0.00	0.22
22	0.00	0.00	-	0.31	1.70	0.00	0.21	0.00	0.00	0.00	-	-	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.08	0.00	0.00	0.25	1.95	0.00	0.04	0.00	0.00	0.00	0.00	0.19	0.13	0.00	-	-	-	0.00	0.00	0.00	0.00
25	0.00	0.00	0.00	0.22	0.00	0.00	0.30	0.00	0.00	0.00	0.00	0.00	0.17	0.00	-	-	-	0.00	0.00	0.00	0.00
27	0.00	0.00	0.00	0.13	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00	-	-	0.00	0.00

Shovelnose Sturgeon

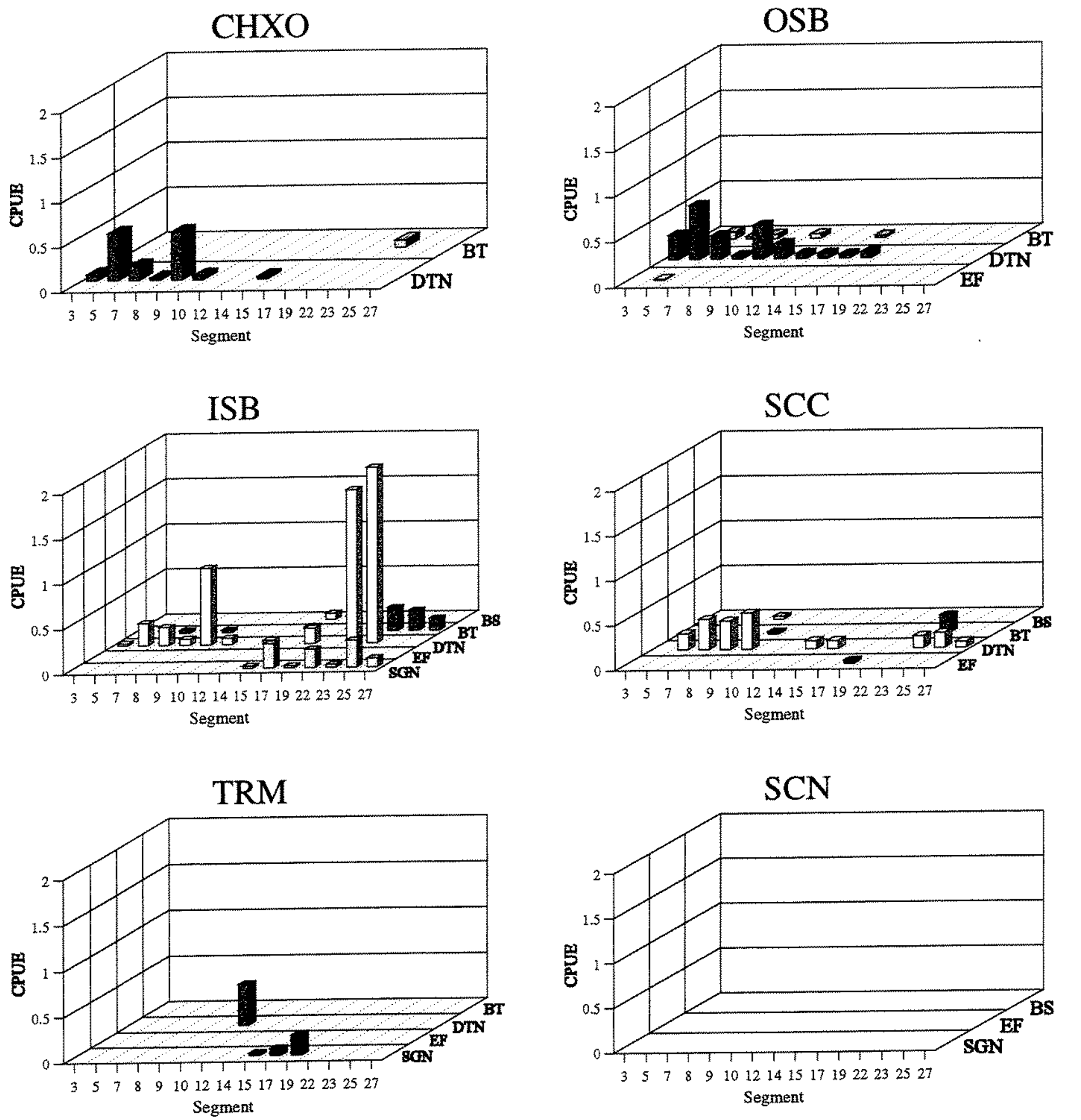
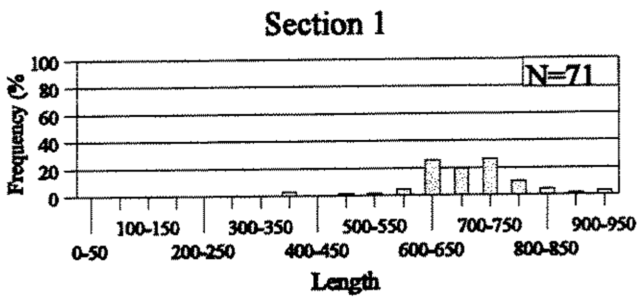
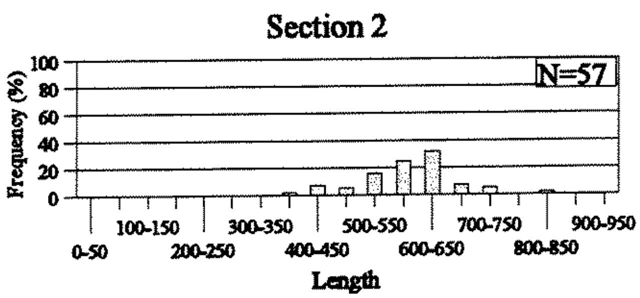
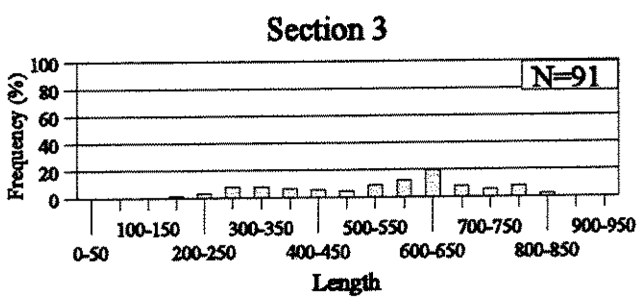


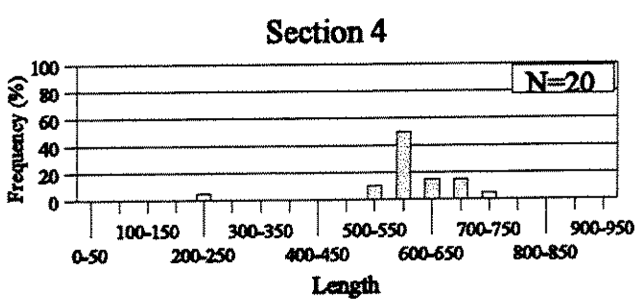
Figure 68. Trends of shovelnose sturgeon catch rates among Missouri and Yellowstone River study segments and macrohabitats in 1997. Catch rates are reported as #fish/100m for benthic trawl (BT) and drifting trammel net (DTN), #fish/180 degree haul for a bag seine (BS), #fish/hr for a statinary gill net (SGN), and #fish/min for electrofishing (EF). See Appendix A for list of macrohabitat acronyms.

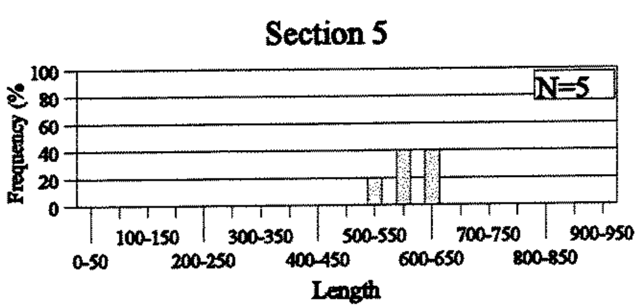
Shovelnose Sturgeon

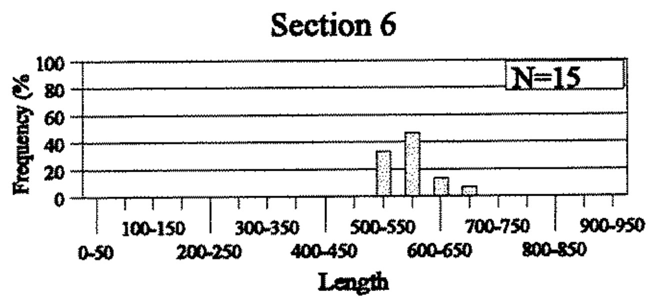


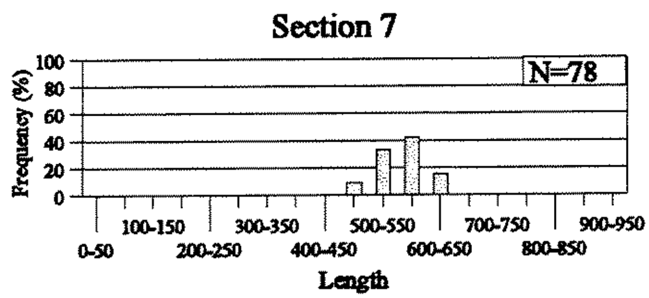


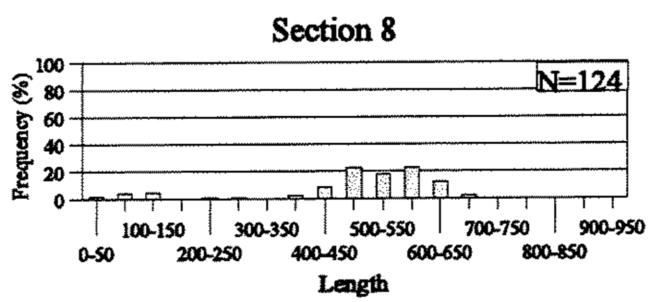












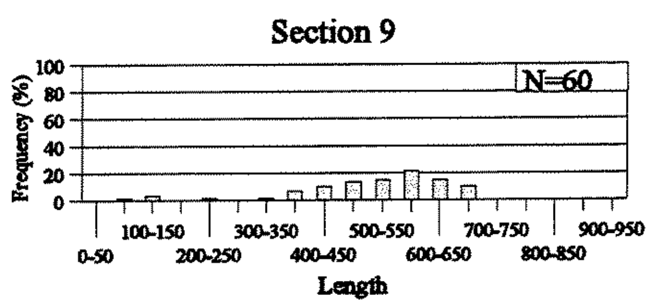


Figure 69. Length-frequency histograms of shovelnose sturgeon collected from Missouri and Yellowstone River sections using drifting trammel nets, experimental gill nets, benthic trawls, bag seines, and boat electrofishing. See Table 1 for section definitons.

Shovelnose Sturgeon

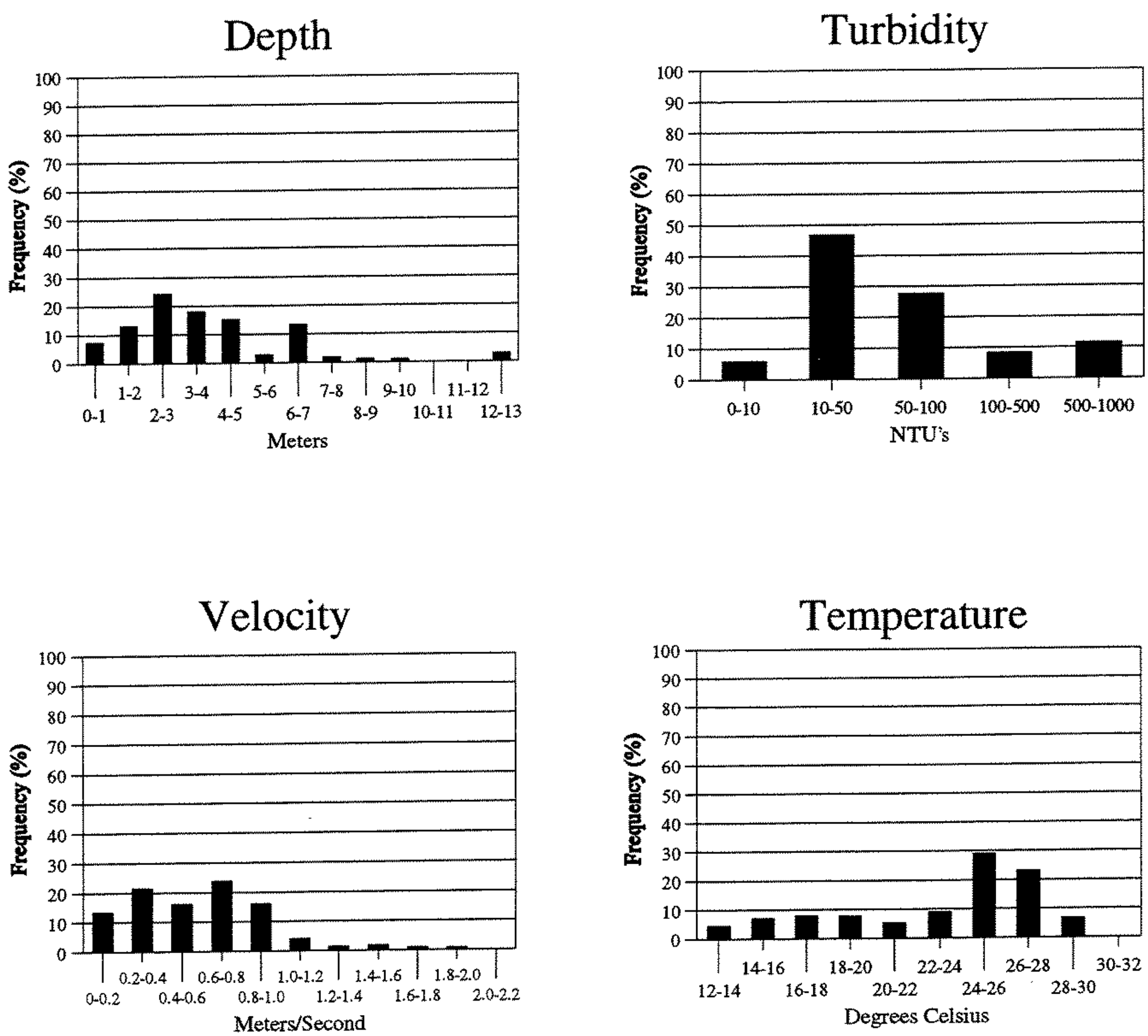


Figure 70. Frequency of occurrence of shovelnose sturgeon (N=525) in various depth, velocity, turbidity, and water temperature intervals from Missouri and Yellowstone River collections.

Sicklefin chub (SFCB)

We collected 212 fish scattered throughout the river in 9 of out 15 study segments (Table 28). The catch of 83 fish in 1996 was distributed similarly. This small minnow with distinctively long pectoral fins grows to about 150 mm in length. We found large and small fish in Sections 1, 2, 8, and 9, indicating that reproduction and recruitment has been successful in these parts of the river (Figure 72).

The fish is said to be adapted to high velocity situations, and our finding that 10-25% of the fish were collected where velocity rates exceeded 1 m/s and depths exceeding 3 m somewhat confirms this hypothesis. Most (80%) sicklefin chubs were found where turbidity levels were 10 to 100 NTUs, but some were in clear water and some in very turbid water (Figure 73). The fish were not associated with any particular temperature. The fish seemed to avoid secondary non-connected channels, but were found in all other habitats (Figure 71). Sicklefin chubs were collected only in the benthic trawl, wheras most benthic guild species were collected in several gears. Our 1997 data confirms conclusions made from the 83 fish collected in 1996.

Sicklefin Chub

Table 28. Catch-Per-Unit-Effort (CPUE) for sicklefin chub by gear, across macrohabitats (CHXO=Channel Cross-Over, ISB=Inside Bend, OSB=Outside Bend, SCC=Secondary Channel Connected, SCN=Secondary Channel Non-Connected, and TRM=Tributary Mouth). Catch rates are reported as #fish/100m for benthic trawl (BT) and drifting trammel net (DTN), #fish/180 degree haul for a bag seine (BS), #fish/hr for a stationary gill net (SGN), and #fish/min for electrofishing (EF). Least-impacted segment numbers = standard font. Inter-reservoir segment numbers = bold font. Channelized segment numbers = italic font. A "-" indicates that no sample was taken.

Segment	CHXO		ISB					OSB			SCC				SCN			TRM			
	BT	DTN	BS	BT	DTN	EF	SGN	BT	DTN	EF	BS	BT	DTN	EF	BS	EF	SGN	BT	DTN	EF	SGN
3	-	0.00	-	-	0.00	0.00	-	-	0.00	0.00	-	-	0.00	0.00	-	-	0.00	-	-	-	-
5	0.60	0.00	-	1.71	0.00	0.00	-	1.06	0.00	0.00	-	1.33	0.00	0.00	-	0.00	0.00	-	-	-	-
7	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00	-	0.00	0.00	0.00	-	0.00	-	0.00	-	-	-	0.00
8	0.18	0.00	0.00	0.09	0.00	-	-	0.09	0.00	-	0.00	0.02	0.00	-	0.00	-	-	-	-	-	-
9	0.11	0.00	0.00	0.35	0.00	-	-	0.21	0.00	-	0.00	0.20	0.00	-	0.00	-	-	-	-	-	-
10	0.18	0.00	0.00	0.26	0.00	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	0.00	0.00	0.00	0.00	0.00	-
12	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00	0.00	0.00	-	-	-	0.00	0.00	0.00	-	-	0.00	0.00
14	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	0.00	0.00	-	-	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	-	-	-	-	-	-	-	0.00	0.00
19	0.00	0.00	-	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	0.00	-	-	-	-	0.00	0.00	0.00
22	0.00	0.00	-	0.06	0.00	0.00	0.00	0.00	0.00	0.00	-	-	-	-	0.00	0.00	0.00	0.07	0.00	0.00	0.00
23	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.11	0.00	0.00	-	-	-	0.00	0.00	0.00	0.00
25	0.08	0.00	0.00	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.00	0.00	-	-	-	0.56	0.00	0.00	0.00
27	0.00	0.00	0.00	0.67	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.43	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00

Sicklefin Chub

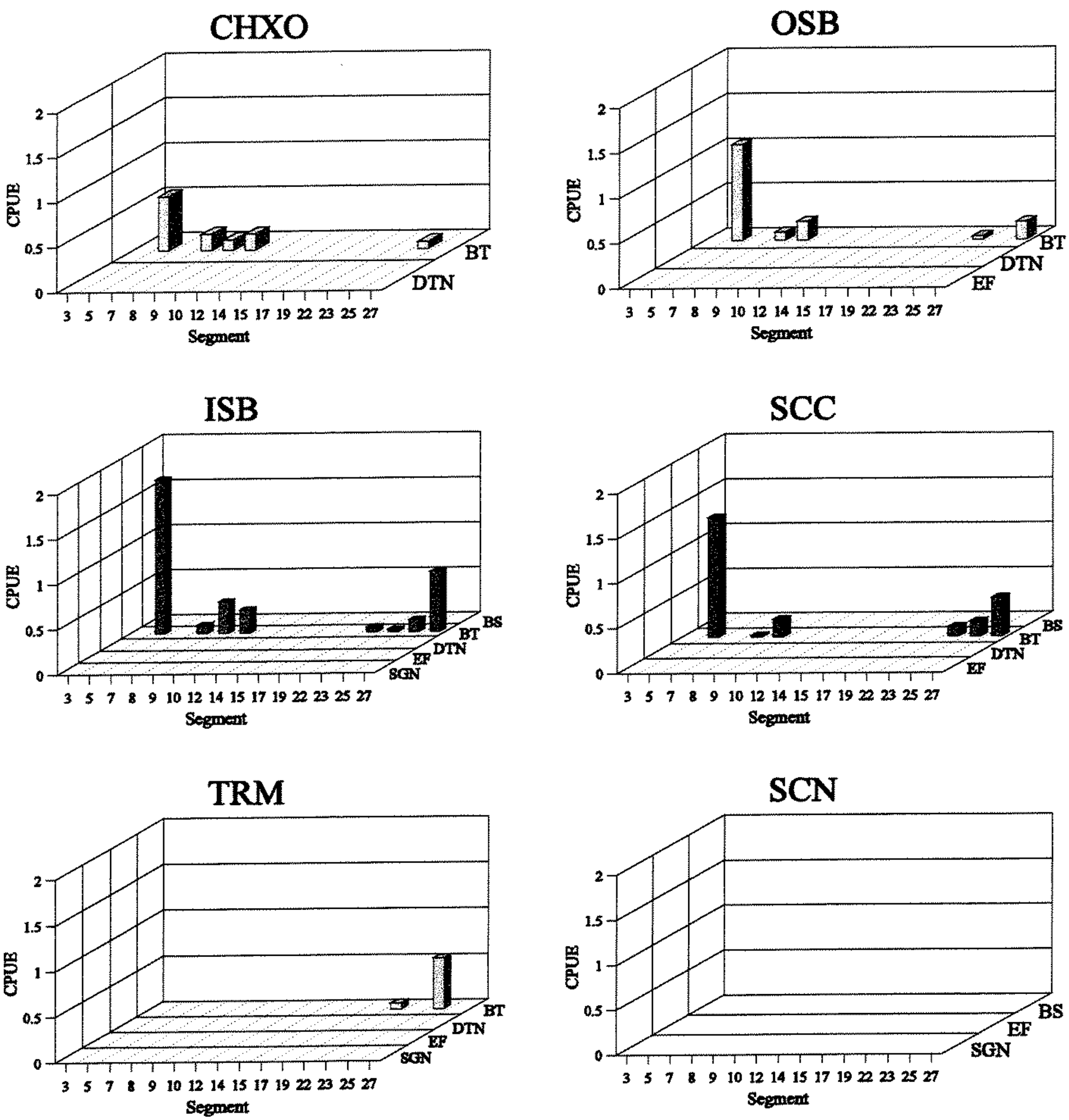
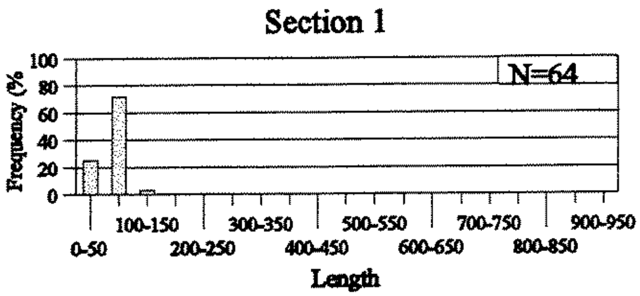
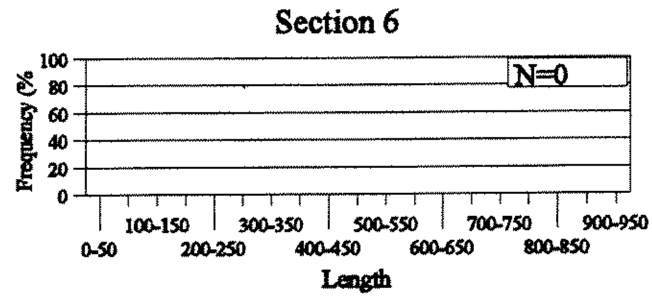
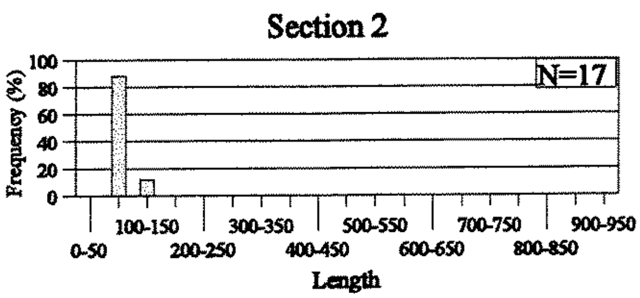


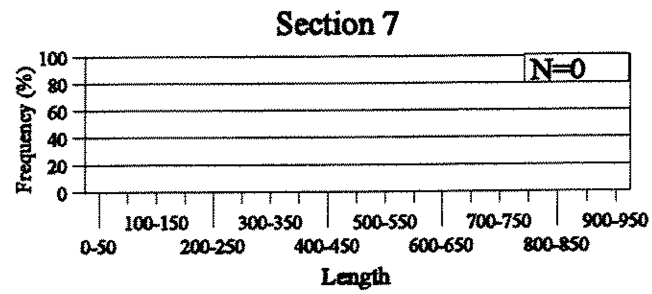
Figure 71. Trends of sicklefin chub catch rates among Missouri and Yellowstone River study segments and macrohabitats in 1997. Catch rates are reported as #fish/100m for benthic trawl (BT) and drifting trammel net (DTN), #fish/180 degree haul for a bag seine (BS), #fish/hr for a statinary gill net (SGN), and #fish/min for electrofishing (EF). See Appendix A for list of macrohabitat acronyms.

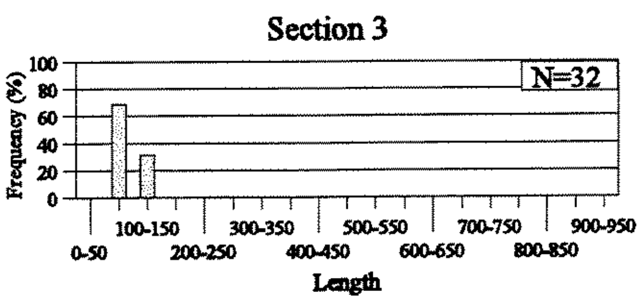
Sicklefin Chub

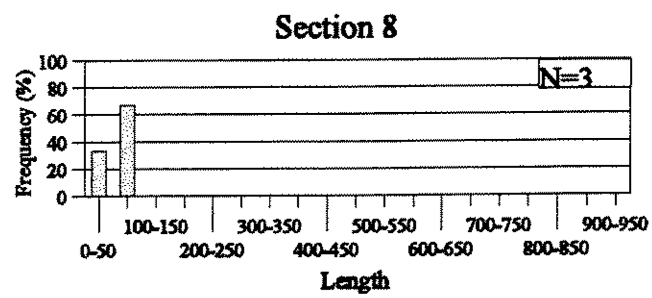


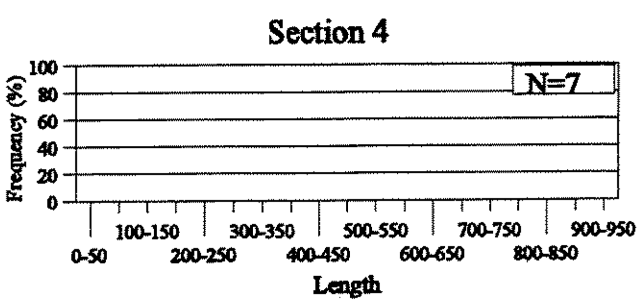


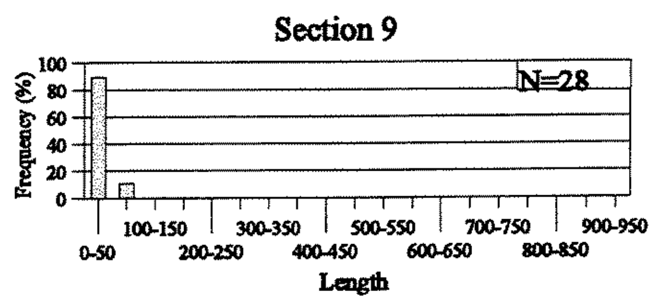












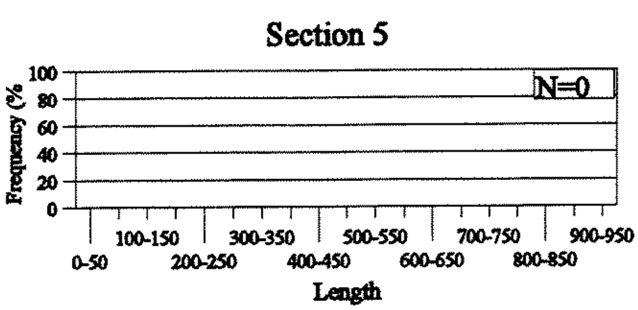


Figure 72. Length-frequency histograms of sicklefin chub collected from Missouri and Yellowstone River sections using drifting trammel nets, experimental gill nets, benthic trawls, bag seines, and boat electrofishing. Remaining data will appear in 1997 Age & Growth Analyses. See Table 1 for section definitons.

Sicklefin Chub

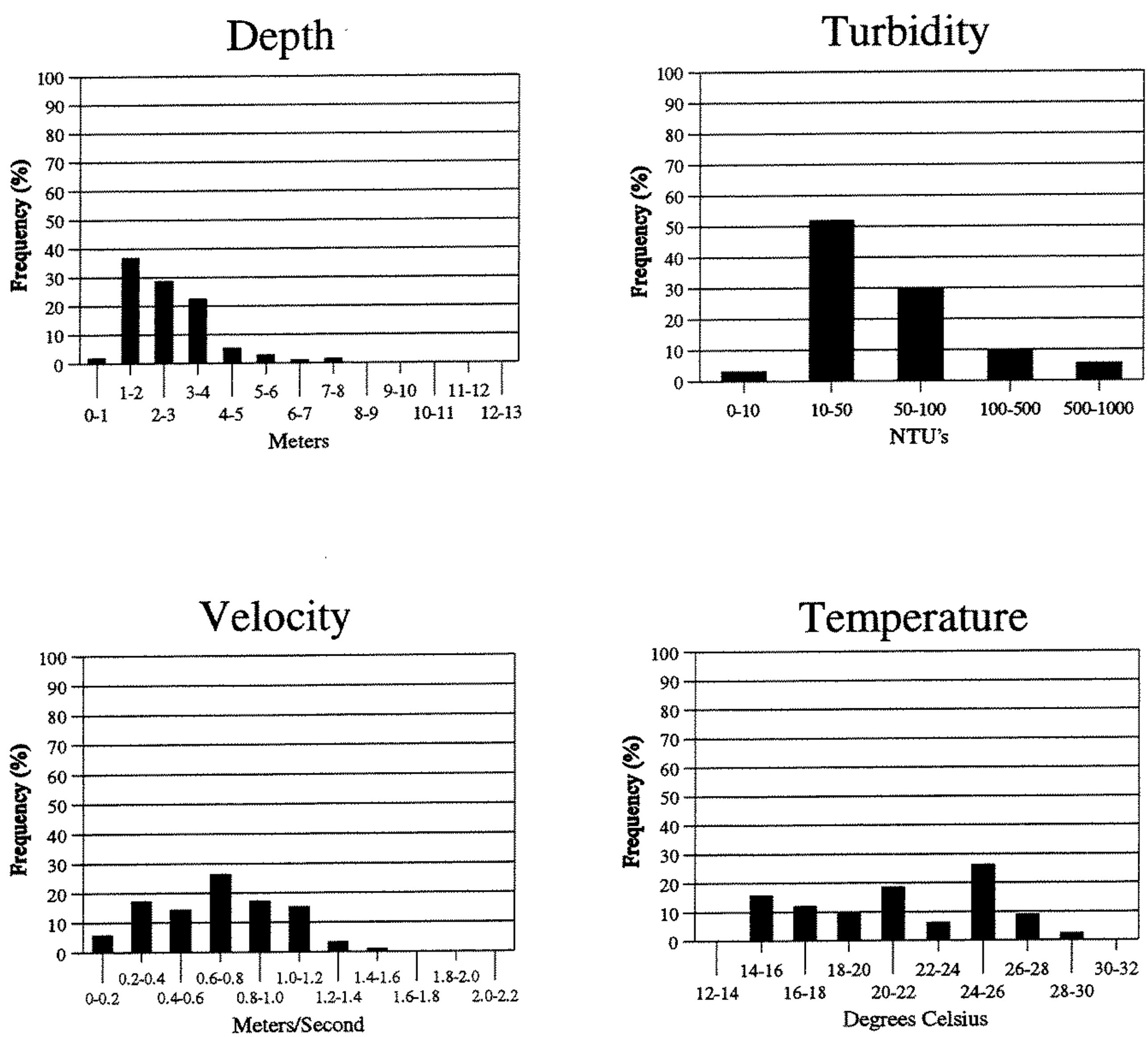


Figure 73. Frequency of occurrence of sicklefin chub (N=210) in various depth, velocity, turbidity, and water temperature intervals from Missouri and Yellowstone River collections.

Smallmouth buffalo (SMBF)

This species occurs as a low-density population that is distributed throughout the river, but the highest catches were in the inter-reservoir areas (Table 29). Fish reach a length of about 700-mm (Figure 75). There was good representation of all size classes in Sections 6, 7, and 9, which are the South Dakota, Iowa, and Missouri Sections, but in other Sections there seemed to be length groups that were missing or not captured. Water quality and hydrological conditions associated with the highest capture rates were: velocity <0.4 m/s, depths <2 m, and turbidity levels <100 NTUs. Some fish were caught at all available water temperatures, but most fish were captured where water temperature was 20-30 °C (Figure 76). Most of the 270 fish captured were collected by electrofishing in non-connected channels and tributary mouths, but fish were also captured in other gears and in all other habitats except channel crossovers (Figure 74), which is a conclusion identical to that from the 1996 field season.

Smallmouth Buffalo

Table 29. Catch-Per-Unit-Effort (CPUE) for smallmouth buffalo by gear, across macrohabitats (CHXO=Channel Cross-Over, ISB=Inside Bend, OSB=Outside Bend, SCC=Secondary Channel Connected, SCN=Secondary Channel Non-Connected, and TRM=Tributary Mouth). Catch rates are reported as #fish/100m for benthic trawl (BT) and drifting trammel net (DTN), #fish/180 degree haul for a bag seine (BS), #fish/hr for a stationary gill net (SGN), and #fish/min for electrofishing (EF). Least-impacted segment numbers = standard font. Inter-reservoir segment numbers = bold font. Channelized segment numbers = italic font. A "-" indicates that no sample was taken.

Segment	CHXO		ISB					OSB			SCC				SCN			TRM			
	BT	DTN	BS	BT	DTN	EF	SGN	BT	DTN	EF	BS	BT	DTN	EF	BS	EF	SGN	BT	DTN	EF	SGN
3	-	0.00	-	-	0.00	0.00	-	-	0.00	0.02	-	-	0.00	0.00	-	-	0.00	-	-	-	-
5	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.00	-	-	-	-
7	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00	-	0.00	0.00	0.00	-	0.00	-	0.00	-	-	-	0.00
8	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00	-	0.00	0.00	0.02	-	3.33	-	-	-	-	-	-
9	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00	-	0.00	0.00	0.04	-	0.00	-	-	-	-	-	-
10	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	0.41	0.00	0.00	0.00	0.00	-
12	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00	0.00	0.00	-	-	-	0.00	0.00	0.00	-	-	0.00	0.00
14	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.00	0.01	0.00	0.00	0.00	0.02	0.00	0.00	0.05	-	-	0.01	0.05
15	0.00	0.00	0.40	0.00	0.00	-	0.00	0.00	0.00	0.02	0.33	0.00	0.00	0.03	-	0.75	0.09	-	-	0.03	0.00
17	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.01	-	-	-	-	-	-	-	-	-	0.12	0.01
19	0.00	0.00	-	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	0.00	-	-	-	-	0.00	0.02	0.00
22	0.00	0.00	-	0.00	0.00	0.00	0.00	0.00	0.00	0.01	-	-	-	-	0.00	0.00	0.00	0.00	0.07	0.01	0.02
23	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00	-	-	-	0.00	0.00	0.01	0.04
25	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	-	-	-	0.00	0.00	0.08	0.04
27	0.00	0.00	0.00	0.00	0.00	0.03	0.01	0.00	0.00	0.01	0.04	0.00	0.00	0.02	0.07	0.05	0.00	-	-	0.07	0.10

Smallmouth Buffalo

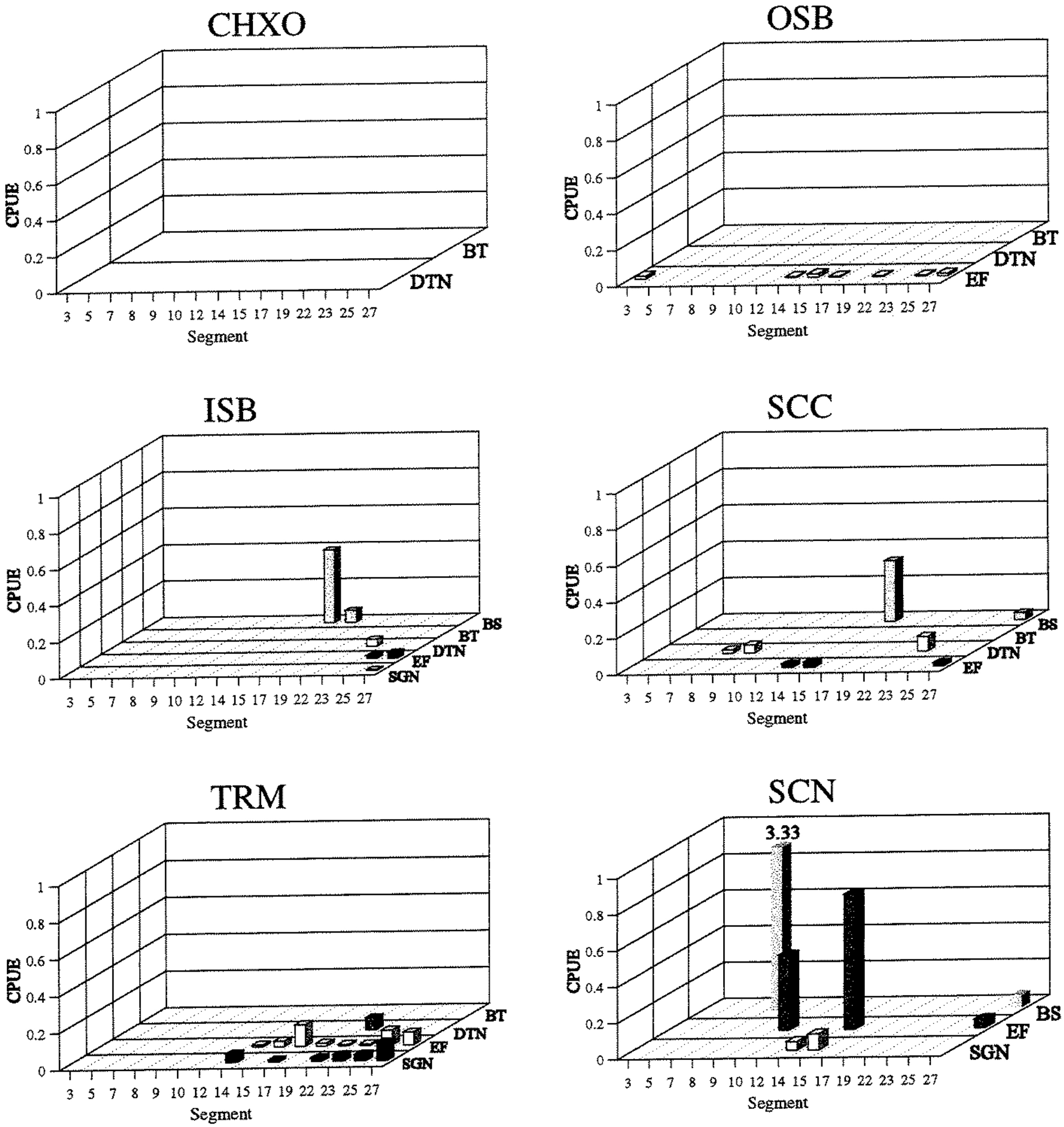
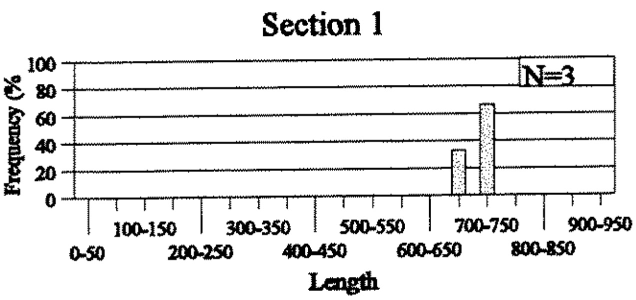
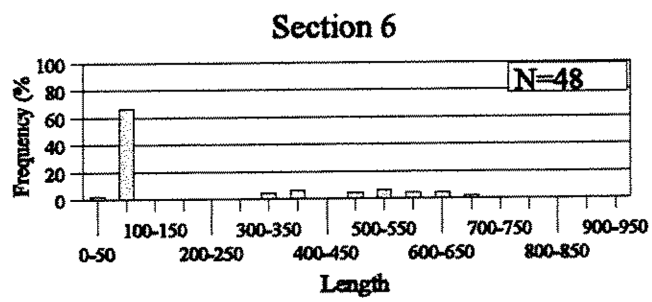
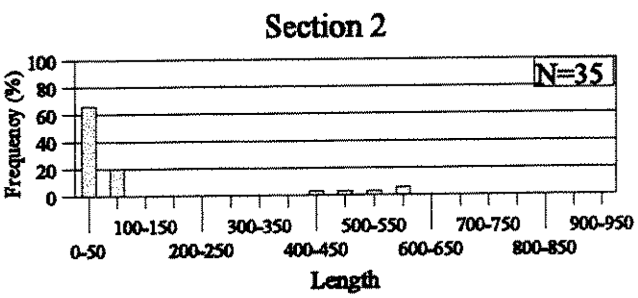


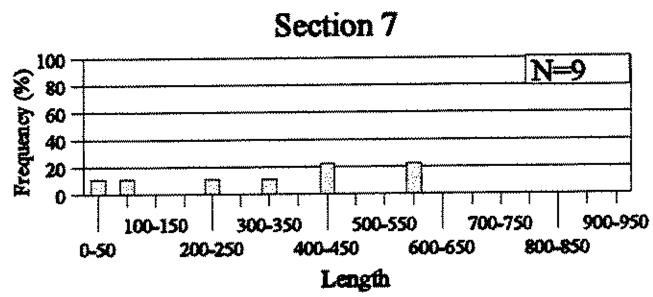
Figure 74. Trends of smallmouth buffalo catch rates among Missouri and Yellowstone River study segments and macrohabitats in 1997. Catch rates are reported as #fish/100m for benthic trawl (BT) and drifting trammel net (DTN), #fish/180 degree haul for a bag seine (BS), #fish/hr for a statinary gill net (SGN), and #fish/min for electrofishing (EF). See Appendix A for list of macrohabitat acronyms.

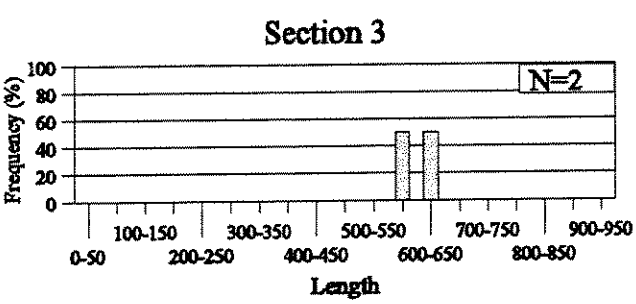
Smallmouth Buffalo

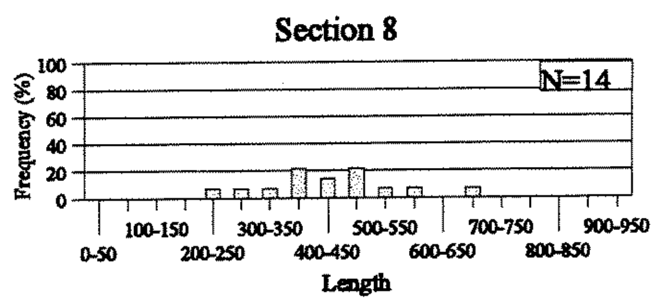


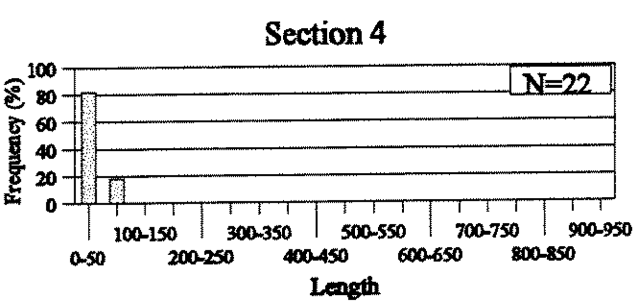


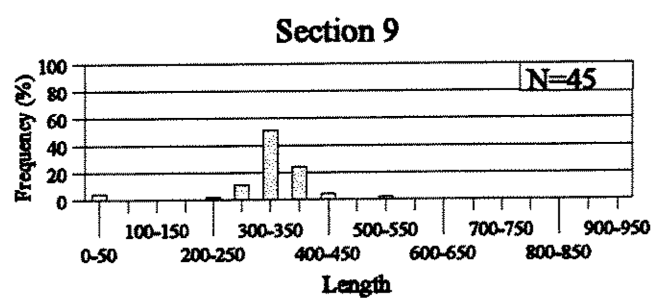












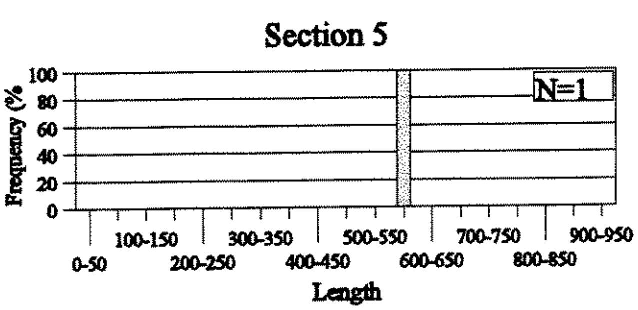


Figure 75. Length-frequency histograms of smallmouth buffalo collected from Missouri and Yellowstone River sections using drifting trammel nets, experimental gill nets, benthic trawls, bag seines, and boat electrofishing. See Table 1 for section definitons.

Smallmouth Buffalo

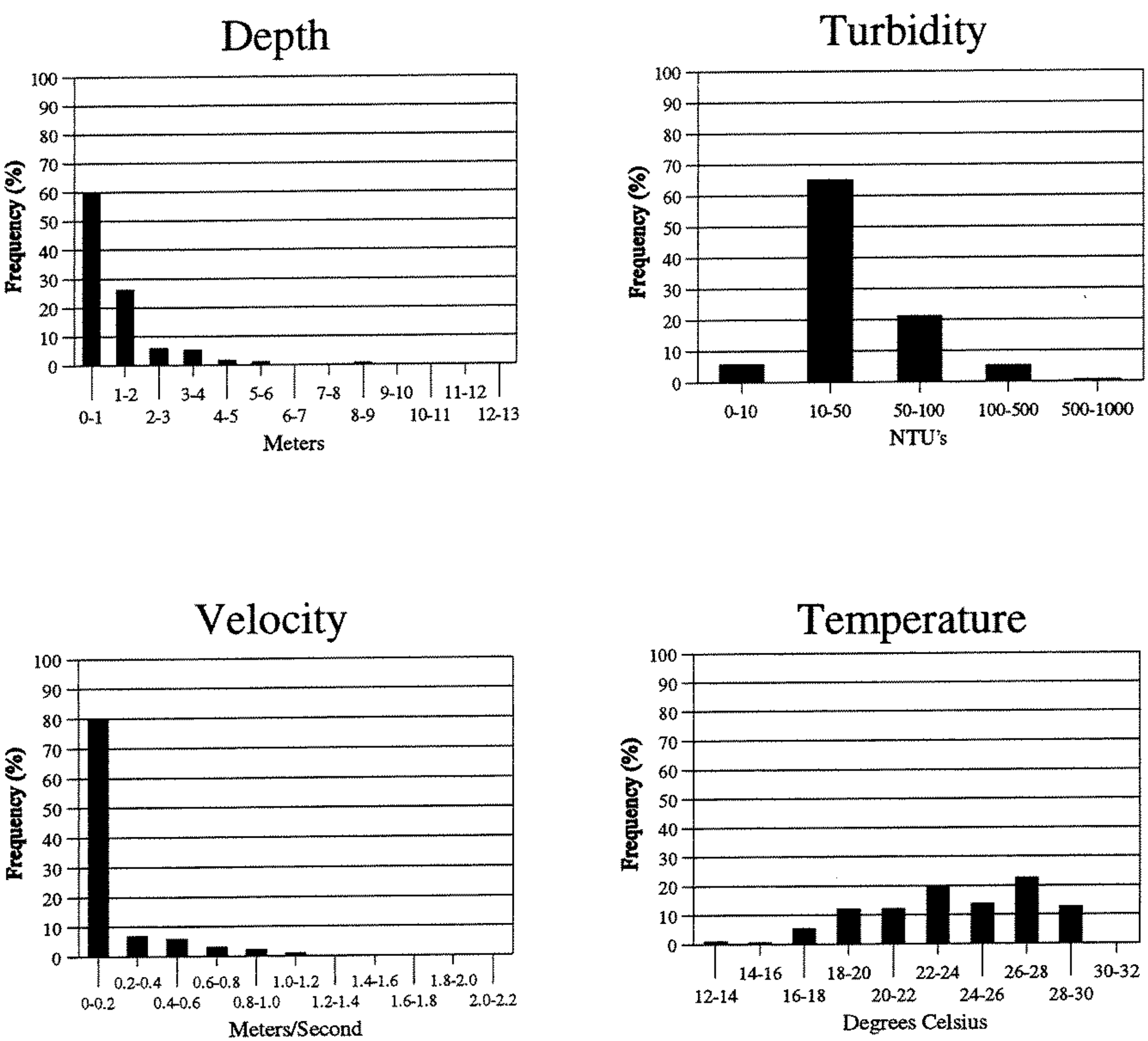


Figure 76. Frequency of occurrence of smallmouth buffalo (N=191) in various depth, velocity, turbidity, and water temperature intervals from Missouri and Yellowstone River collections.

Stonecat (STCT)

A total of 128 stonecats was captured. Fish were captured in all macrohabitats except TRM and with all gears except stationary gill nets (Figure 77). Highest CPUE's were obtained with the benthic trawl in least impacted segment 5 in OSBs and CHXOs (Table 30). Few stonecats were captured in channelized segments below Gavins Point Dam.

Stonecats were captured in a wide range of depths (0 to 10 m), turbidities (0 to 1000 NTUs), velocities (0.2 to 1.6 m/s), and temperatures (12°C to 28°C) (Figure 79). However, most fish were captured in water with depths less than 4 m (73%), turbidities less than 100 NTUs (63%), velocities greater than 0.8 m/s (63%), and temperatures greater than 20°C (78%).

No stonecats were captured in inter-reservoir section 5 or in channelized sections 7 and 9. Section 1 had the largest portion of fish with lengths from 0-100 mm, which suggests good recruitment (Figure78). Sections 1, 2, 4, and 6 had fish greater than 150mm in length.

Stonecat

Table 30. Catch-Per-Unit-Effort (CPUE) for stonecat by gear, across macrohabitats (CHXO=Channel Cross-Over, ISB=Inside Bend, OSB=Outside Bend, SCC=Secondary Channel Connected, SCN=Secondary Channel Non-Connected, and TRM=Tributary Mouth). Catch rates are reported as #fish/100m for benthic trawl (BT) and drifting trammel net (DTN), #fish/180 degree haul for a bag seine (BS), #fish/hr for a stationary gill net (SGN), and #fish/min for electrofishing (EF). Least-impacted segment numbers = standard font. Inter-reservoir segment numbers = bold font. Channelized segment numbers = italic font. A "-" indicates that no sample was taken.

Segment	CHXO		ISB					OSB			SCC				SCN			TRM			
	BT	DTN	BS	BT	DTN	EF	SGN	BT	DTN	EF	BS	BT	DTN	EF	BS	EF	SGN	BT	DTN	EF	SGN
3	-	0.00	-	-	0.00	0.00	-	-	0.00	0.01	-	-	0.00	0.00	-	-	0.00	-	-	-	-
5	0.75	0.04	-	0.28	0.00	0.02	-	1.56	0.00	0.04	-	0.13	0.00	0.00	-	0.00	0.00	-	-	-	-
7	0.00	0.00	0.00	0.00	0.00	-	-	0.05	0.00	-	0.00	0.00	0.00	-	0.00	-	0.00	-	-	-	0.00
8	0.00	0.00	0.00	0.00	0.00	-	-	0.09	0.00	-	0.00	0.02	0.00	-	0.00	-	-	-	-	-	-
9	0.02	0.00	0.00	0.09	0.00	-	-	0.54	0.00	-	0.00	0.27	0.00	-	0.06	-	-	-	-	-	-
10	0.00	0.00	0.00	0.00	0.00	-	-	0.17	0.00	0.00	0.00	0.00	0.00	0.00	-	0.00	0.00	0.00	0.00	0.00	-
12	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00	0.00	0.00	-	-	-	0.00	0.00	0.00	-	-	0.00	0.00
14	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	0.00	0.00	-	-	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	-	-	-	-	-	-	-	0.00	0.00
19	0.00	0.00	-	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	0.00	-	-	-	-	0.00	0.00	0.00
22	0.00	0.00	-	0.06	0.00	0.00	0.00	0.00	0.00	0.00	-	-	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	-	-	-	0.00	0.00	0.00	0.00
25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	-	0.00	0.00	0.00	0.00
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00

Stonecat

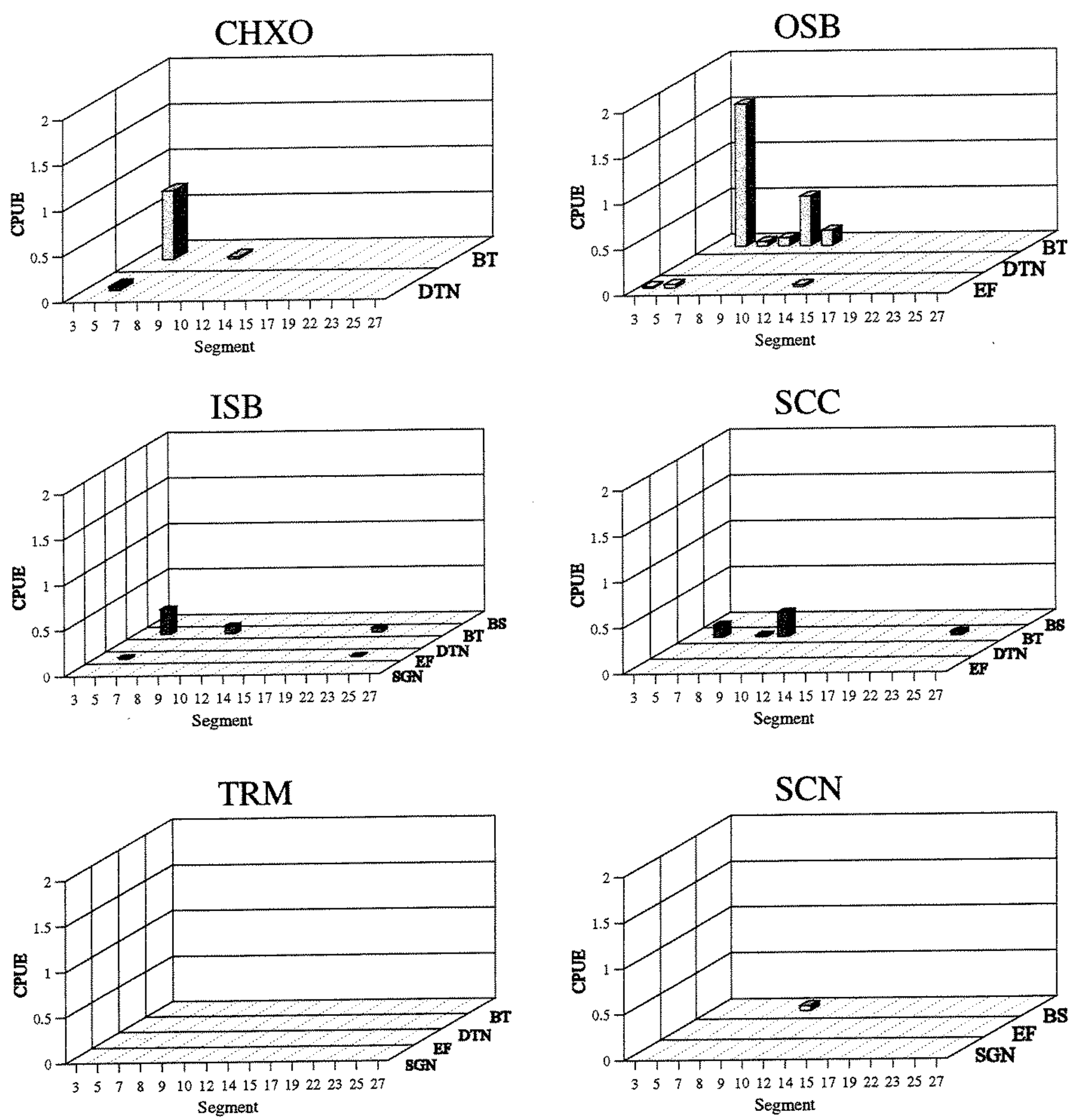
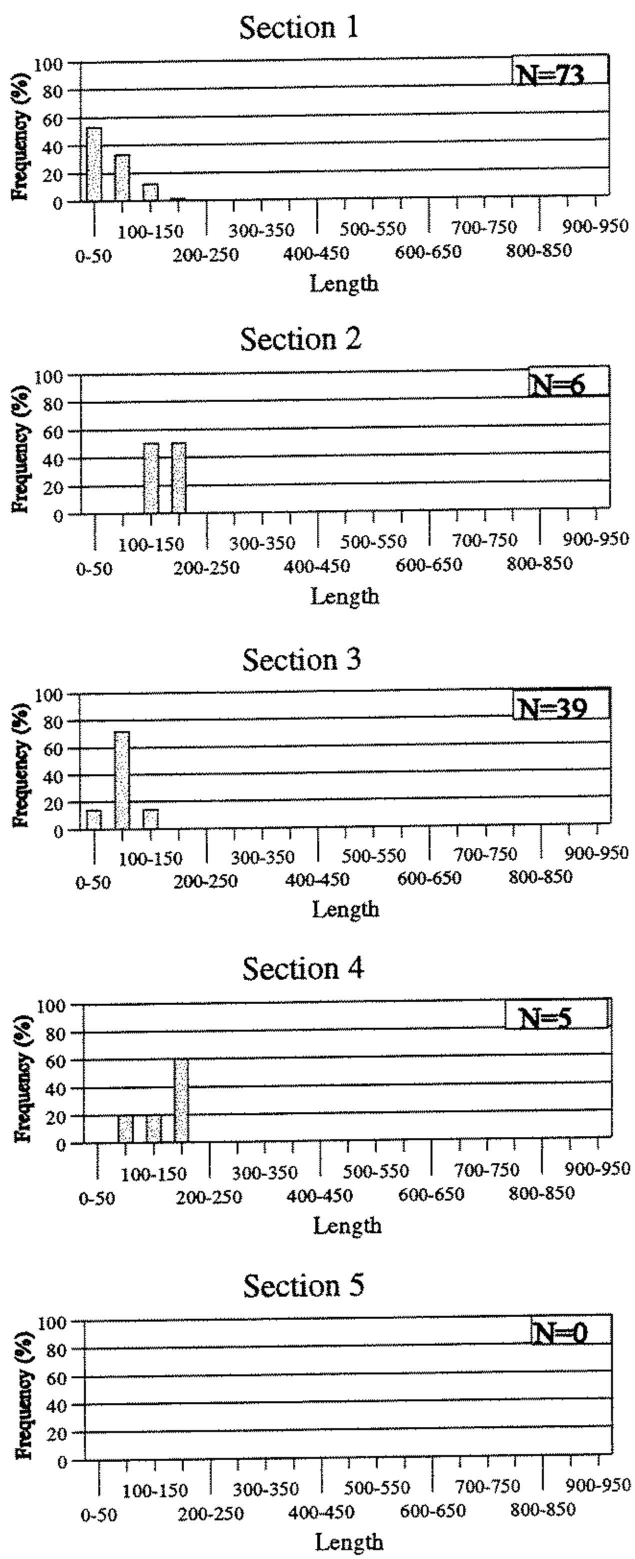


Figure 77. Trends of stonecat catch rates among Missouri and Yellowstone River study segments and macrohabitats in 1997. Catch rates are reported as #fish/100m for benthic trawl (BT) and drifting trammel net (DTN), #fish/180 degree haul for a bag seine (BS), #fish/hr for a statinary gill net (SGN), and #fish/min for electrofishing (EF). See Appendix A for list of macrohabitat acronyms.

Stonecat



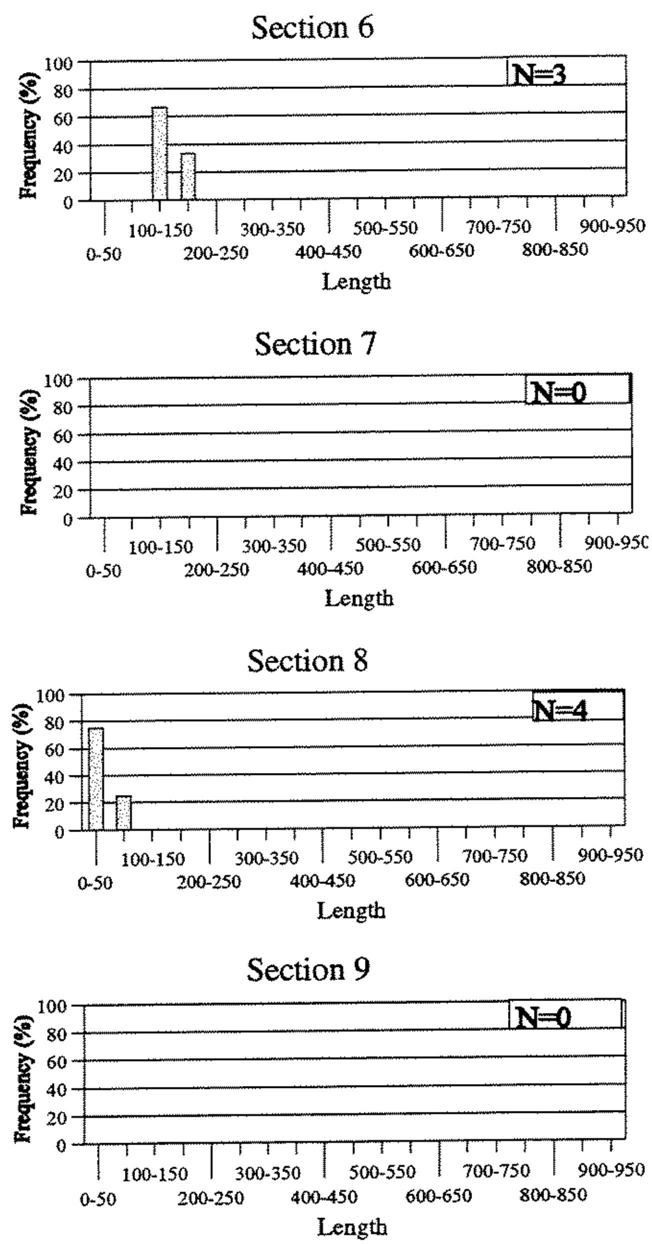


Figure 78. Length-frequency histograms of stonecat collected from Missouri and Yellowstone River sections using drifting trammel nets, experimental gill nets, benthic trawls, bag seines, and boat electrofishing. See Table 1 for section definitons.

Stonecat

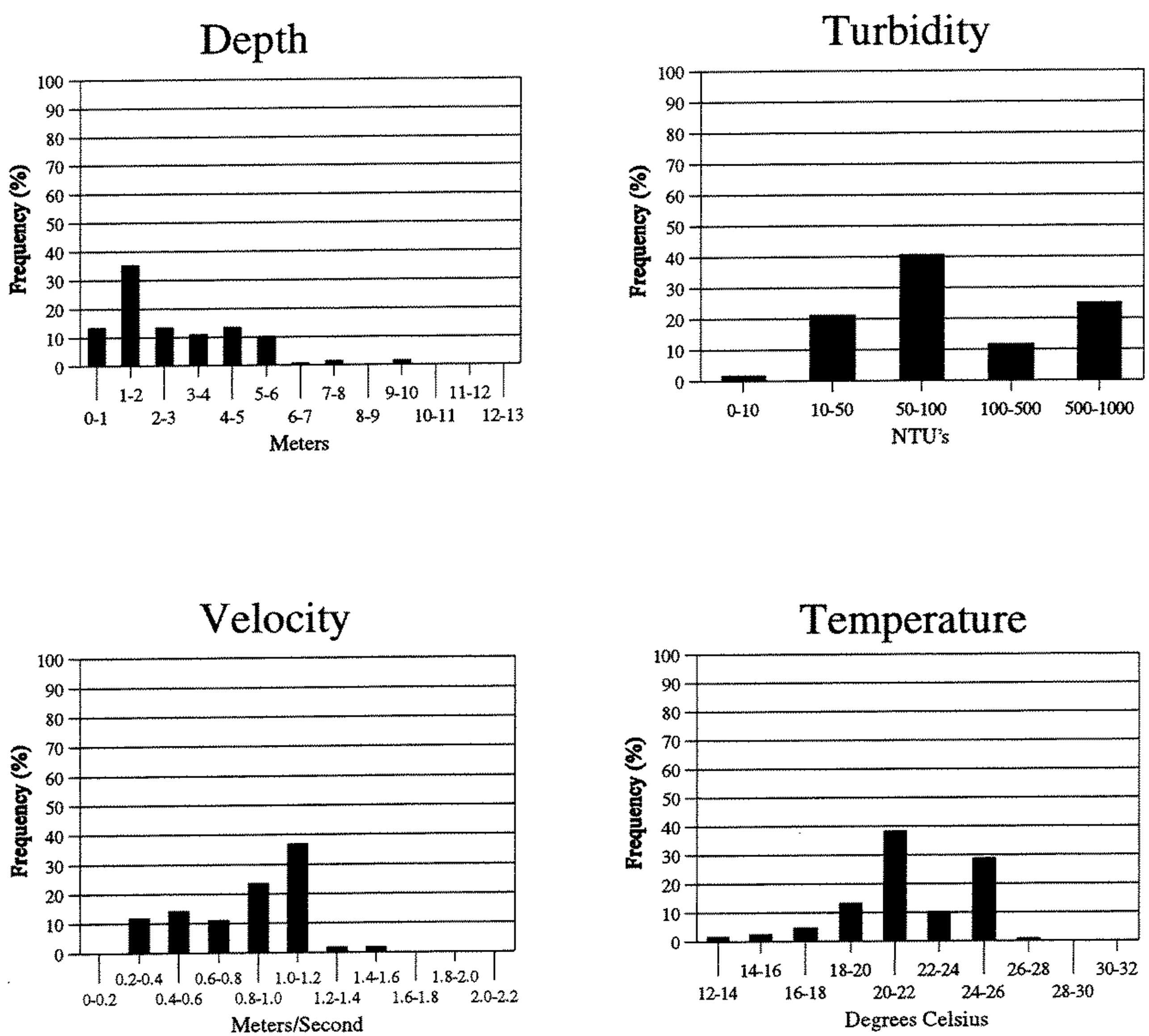


Figure 79. Frequency of occurrence of stonecat (N=128) in various depth, velocity, turbidity, and water temperature intervals from Missouri and Yellowstone River collections.

Sturgeon chub (SGCB)

Catch of this rare fish increased from 344 fish in 1996 to 546 fish in 1997. The species is widely distributed, being found in 10 of our 15 segments. A similar pattern was found in 1996. Most fish were less than 150-mm long, and we usually found small size classes, which is evidence that recruitment has been successful (Figure 81). Like the sicklefin chub, the sturgeon chub is more vulnerable to being collected by trawling than most species, however, some were also collected in seines (Table 31, Figure 80). The fish seems to prefer the main channel habitats, and was not found in tributary mouths or in non-connected secondary channels (Figure 80), which is a conclusion identical to that made using 1996 data. Sturgeon chubs are thought to be a generalist species that tolerate a wide variety of habitat conditions. The broad range of habitat conditions over which they were collected tends to support this idea (Figure 82). One difference between years is that in 1996, most fish were collected at temperatures from 20-25 °C, whereas in 1997, most were collected at temperatures from 14-20 °C.

Sturgeon Chub

Table 31. Catch-Per-Unit-Effort (CPUE) for sturgeon chub by gear, across macrohabitats (CHXO=Channel Cross-Over, ISB=Inside Bend, OSB=Outside Bend, SCC=Secondary Channel Connected, SCN=Secondary Channel Non-Connected, and TRM=Tributary Mouth). Catch rates are reported as #fish/100m for benthic trawl (BT) and drifting trammel net (DTN), #fish/180 degree haul for a bag seine (BS), #fish/hr for a stationary gill net (SGN), and #fish/min for electrofishing (EF). Least-impacted segment numbers = standard font. Inter-reservoir segment numbers = bold font. Channelized segment numbers = italic font. A "-" indicates that no sample was taken.

Segment	CHXO		ISB					OSB			SCC				SCN			TRM			
	BT	DTN	BS	BT	DTN	EF	SGN	BT	DTN	EF	BS	BT	DTN	EF	BS	EF	SGN	BT	DTN	EF	SGN
3	-	0.00	-	-	0.00	0.00	-	-	0.00	0.00	-	-	0.00	0.00	-	-	0.00	-	-	-	-
5	2.01	0.00	-	1.65	0.00	0.00	-	2.15	0.00	0.00	-	1.36	0.00	0.00	-	0.00	0.00	-	-	-	-
7	0.09	0.00	0.00	0.02	0.00	-	-	0.04	0.00	-	0.00	0.04	0.00	-	0.00	-	0.00	-	-	-	
8	0.07	0.00	0.00	0.11	0.00	-	-	0.47	0.00	-	0.00	0.22	0.00	-	0.00	-	-	-	-	-	-
9	1.96	0.00	0.27	0.98	0.00	-	-	0.90	0.00	-	0.33	2.44	0.00	-	0.22	-	-	-	-	-	-
10	0.00	0.00	0.25	0.67	0.00	-	-	0.33	0.00	0.00	0.00	0.22	0.00	0.00	-	0.00	0.00	0.00	0.00	0.00	-
12	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00	0.00	0.00	-	-	-	0.00	0.00	0.00	-	-	0.00	0.00
14	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	0.00	0.00	-	-	0.00	0.00
17	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.07	0.00	0.00	-	-	-	-	-	-	-	-	-	0.00	0.00
19	0.00	0.00	-	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	0.00	-	-	-	-	0.00	0.00	0.00
22	0.00	0.00	-	0.06	0.00	0.00	0.00	0.04	0.00	0.01	-	-	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.04	0.00	0.00	0.08	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.30	0.00	0.00	-	-	-	0.00	0.00	0.00	0.00
25	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.29	0.00	0.00	-	-	-	0.00	0.00	0.00	0.00
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00

Sturgeon Chub

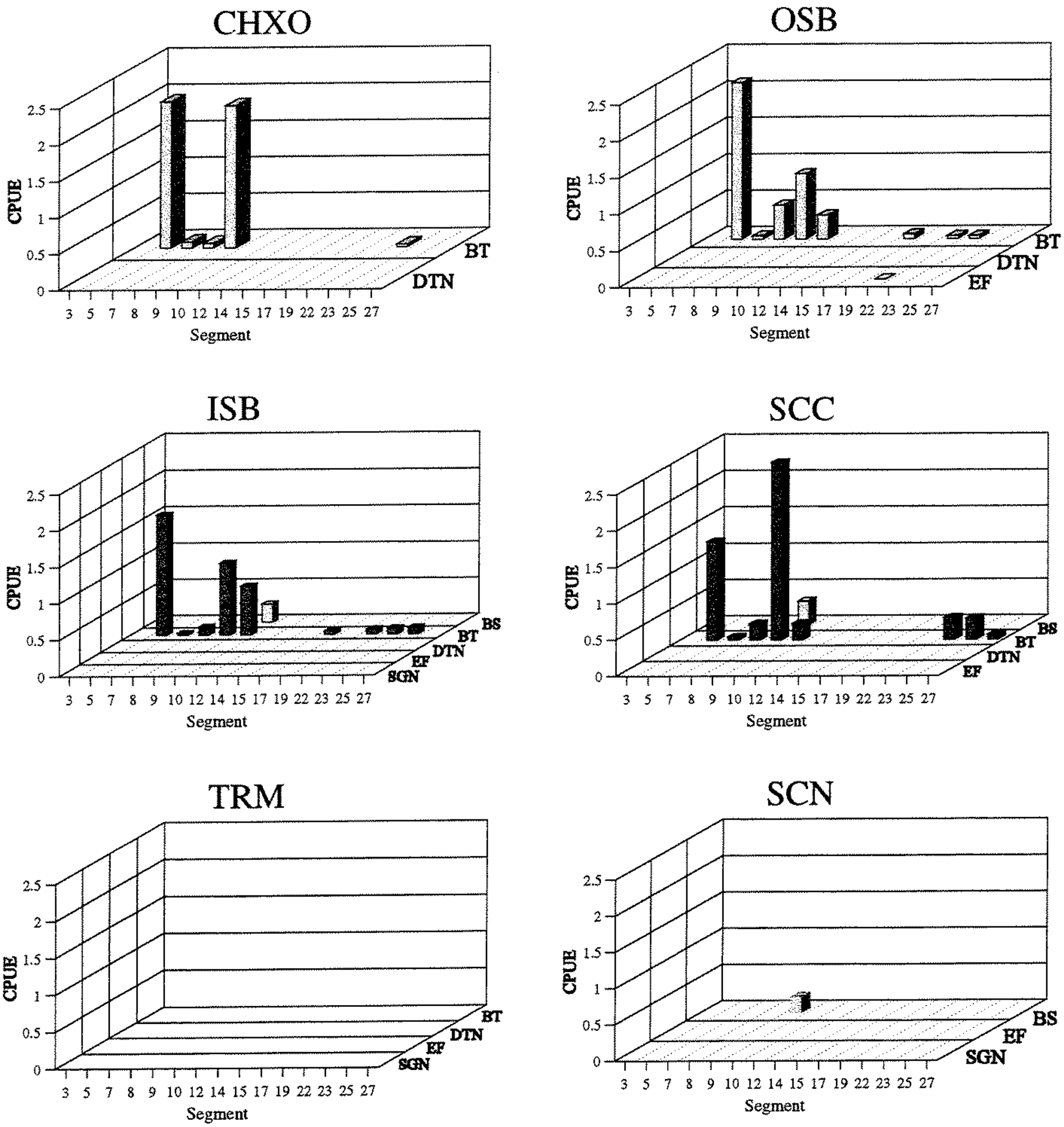
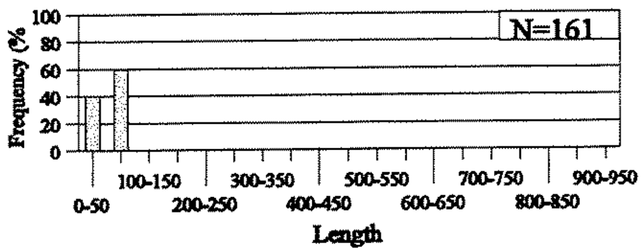


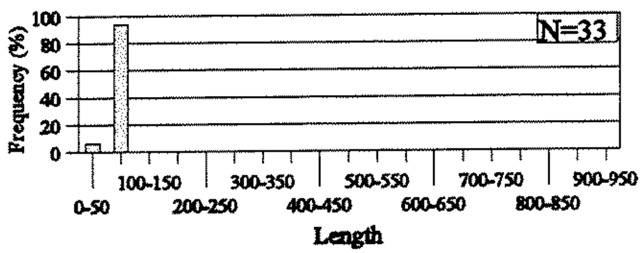
Figure 80. Trends of sturgeon chub catch rates among Missouri and Yellowstone River study segments and macrohabitats in 1997. Catch rates are reported as #fish/100m for benthic trawl (BT) and drifting trammel net (DTN), #fish/180 degree haul for a bag seine (BS), #fish/hr for a statinary gill net (SGN), and #fish/min for electrofishing (EF). See Appendix A for list of macrohabitat acronyms.

Sturgeon Chub

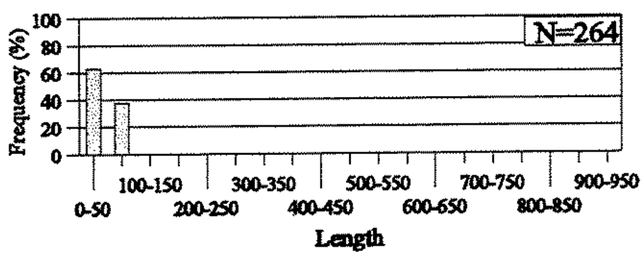
Section 1



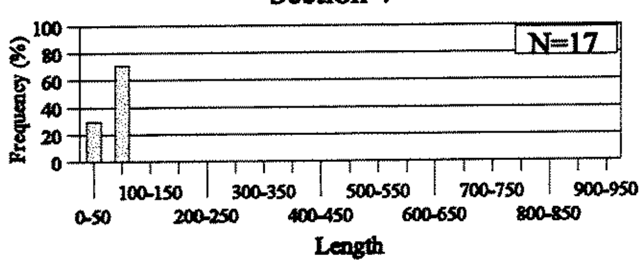
Section 2



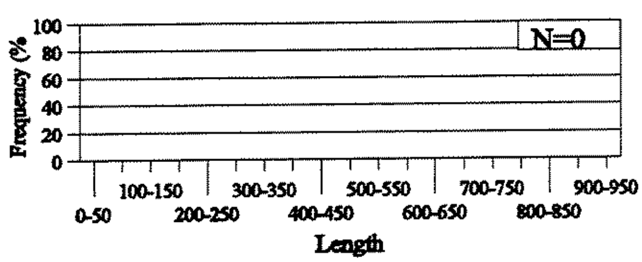
Section 3



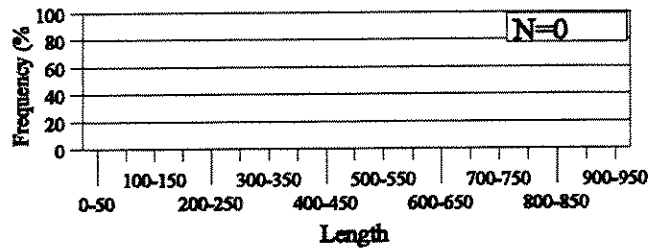
Section 4



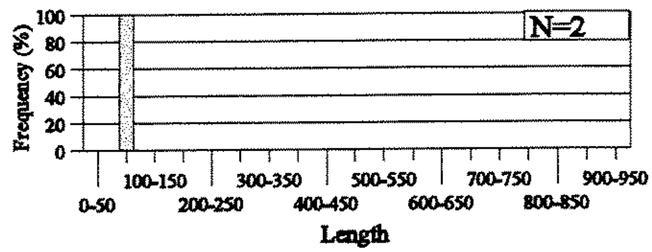
Section 5



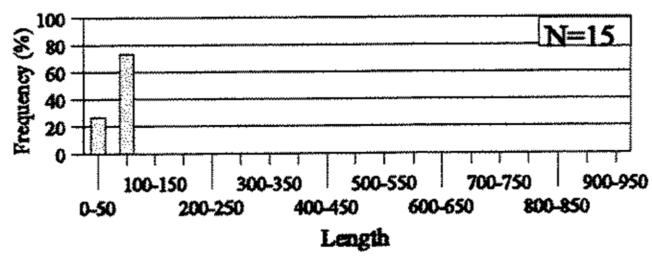
Section 6



Section 7



Section 8



Section 9

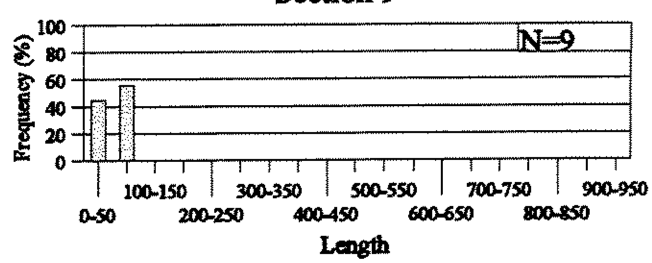


Figure 81. Length-frequency histograms of sturgeon chub collected from Missouri and Yellowstone River sections using drifting trammel nets, experimental gill nets, benthic trawls, bag seines, and boat electrofishing. Remaining data will appear in 1997 Age & Growth Analyses. See Table 1 for section definitons.

Sturgeon Chub

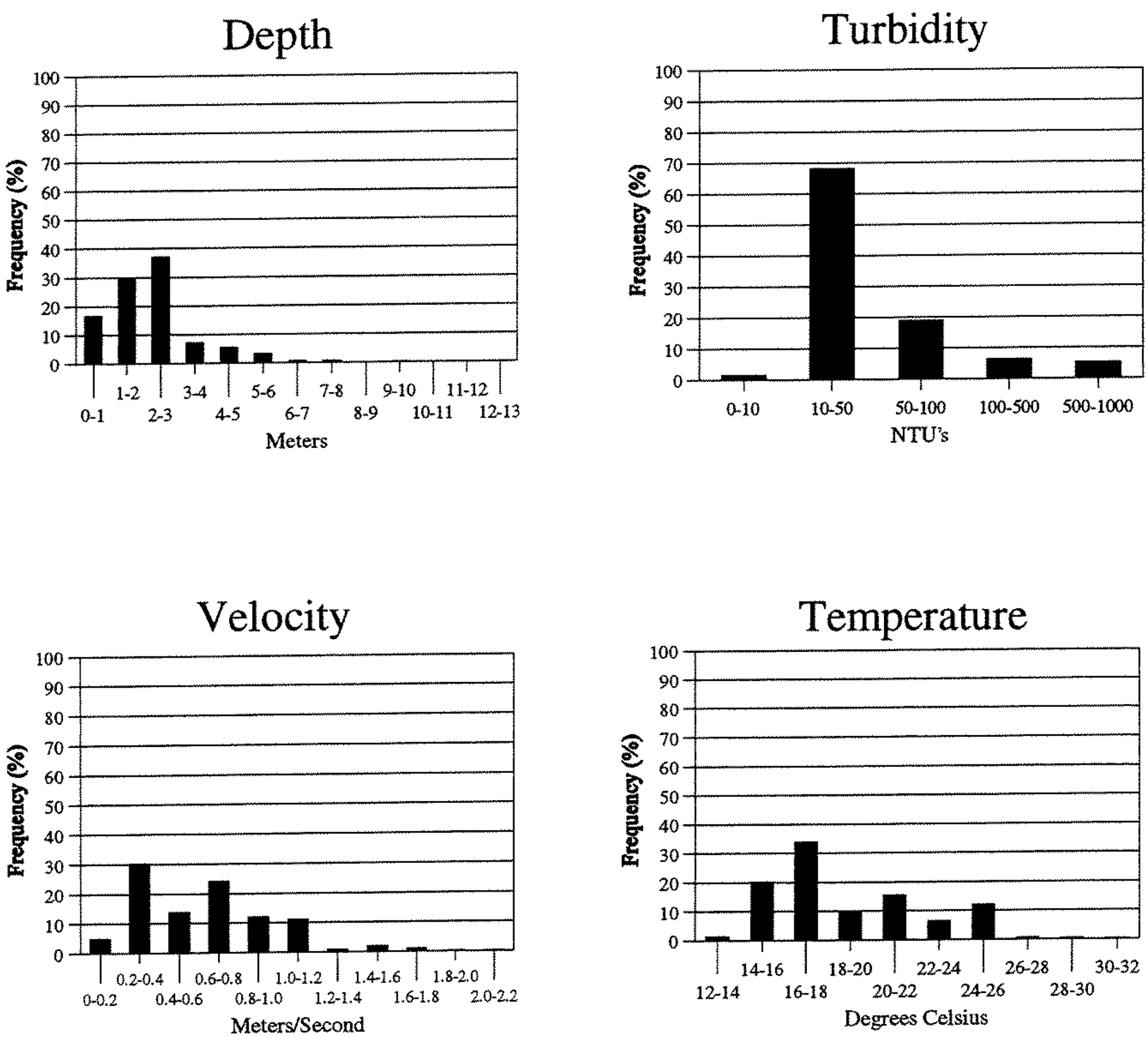


Figure 82. Frequency of occurrence of sturgeon chub (N=520) in various depth, velocity, turbidity, and water temperature intervals from Missouri and Yellowstone River collections.

Walleye (WLYE)

A total of 239 walleye was captured in 1997. Walleye were found in all macrohabitats, except CHXO, and were captured in all segments except channelized segment 25 (Figure 83). Walleye were captured with all gears. Highest CPUE's were obtained in inter-reservoir segments **8** in SCN with the bag seine (1.67/haul), and in segment **15** with the electrofishing boat in SCN (0.42/min) and TRM (0.51/min) (Table 32).

As with sauger, most walleye were captured in shallow water (79% in depths < 2 m) exhibiting low turbidities (74% in turbidities < 50 NTUs) and low velocities (69% in velocities < 0.2 m/s) (Figure 85). Walleye were captured in a wide range of water temperatures (12-30°C), but more than 65% of the fish were captured in water temperatures ranging from 18°C to 26°C. Less than 10 % of all walleye were captured in water with depths greater than 4 m, current velocities greater than 1.0 m/s, and temperatures less than 18°C.

Catches in sections 2, 3, and 6 were dominated by fish less than 150 mm in length, but length frequency distributions in sections 2 and 3 lacked continuity. No walleye less than 50 mm were captured in any section in 1997 (Figure 84) and several sections had fish of only one or two length categories. All fish captured in sections 3 and 9 were 100-150 mm in length, whereas all fish captured in section 8 were between 450 and 550 mm.

Walleye

Table 32. Catch-Per-Unit-Effort (CPUE) for walleye by gear, across macrohabitats (CHXO=Channel Cross-Over, ISB=Inside Bend, OSB=Outside Bend, SCC=Secondary Channel Connected, SCN=Secondary Channel Non-Connected, and TRM=Tributary Mouth). Catch rates are reported as #fish/100m for benthic trawl (BT) and drifting trammel net (DTN), #fish/180 degree haul for a bag seine (BS), #fish/hr for a stationary gill net (SGN), and #fish/min for electrofishing (EF). Least-impacted segment numbers = standard font. Inter-reservoir segment numbers = bold font. Channelized segment numbers = italic font. A "-" indicates that no sample was taken.

Segment	CHXO		ISB					OSB			SCC				SCN			TRM			
	BT	DTN	BS	BT	DTN	EF	SGN	BT	DTN	EF	BS	BT	DTN	EF	BS	EF	SGN	BT	DTN	EF	SGN
3	-	0.00	-	-	0.00	0.00	-	-	0.00	0.03	-	-	0.00	0.20	-	-	0.00	-	-	-	-
5	0.00	0.00	-	0.00	0.00	0.07	-	0.00	0.00	0.07	-	0.00	0.00	0.06	-	0.10	0.00	-	-	-	-
7	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00	-	0.00	0.00	0.00	-	0.00	-	0.00	-	-	-	0.00
8	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00	-	0.03	0.00	0.03	-	1.67	-	-	-	-	-	-
9	0.00	0.00	0.07	0.00	0.00	-	-	0.00	0.00	-	0.03	0.00	0.00	-	0.00	-	-	-	-	-	-
10	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00	0.02	0.00	0.00	0.00	0.00	-	0.03	0.00	0.00	0.00	0.00	-
12	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00	0.00	0.00	-	-	-	0.00	0.03	0.02	-	-	0.35	0.03
14	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.04	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	0.07	0.16
15	0.00	0.00	0.27	0.00	0.00	-	0.01	0.00	0.00	0.11	0.19	0.02	0.00	0.07	-	0.42	0.18	-	-	0.51	0.04
17	0.00	0.00	0.33	0.00	0.00	0.05	0.00	0.00	0.00	0.00	-	-	-	-	-	-	-	-	-	0.00	0.03
19	0.00	0.00	-	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	0.00	-	-	-	-	0.00	0.00	0.09
22	0.00	0.00	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.01
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	-	0.00	0.00	0.00	0.01
25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	-	0.00	0.00	0.00	0.00
27	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	0.01	0.00

Walleye

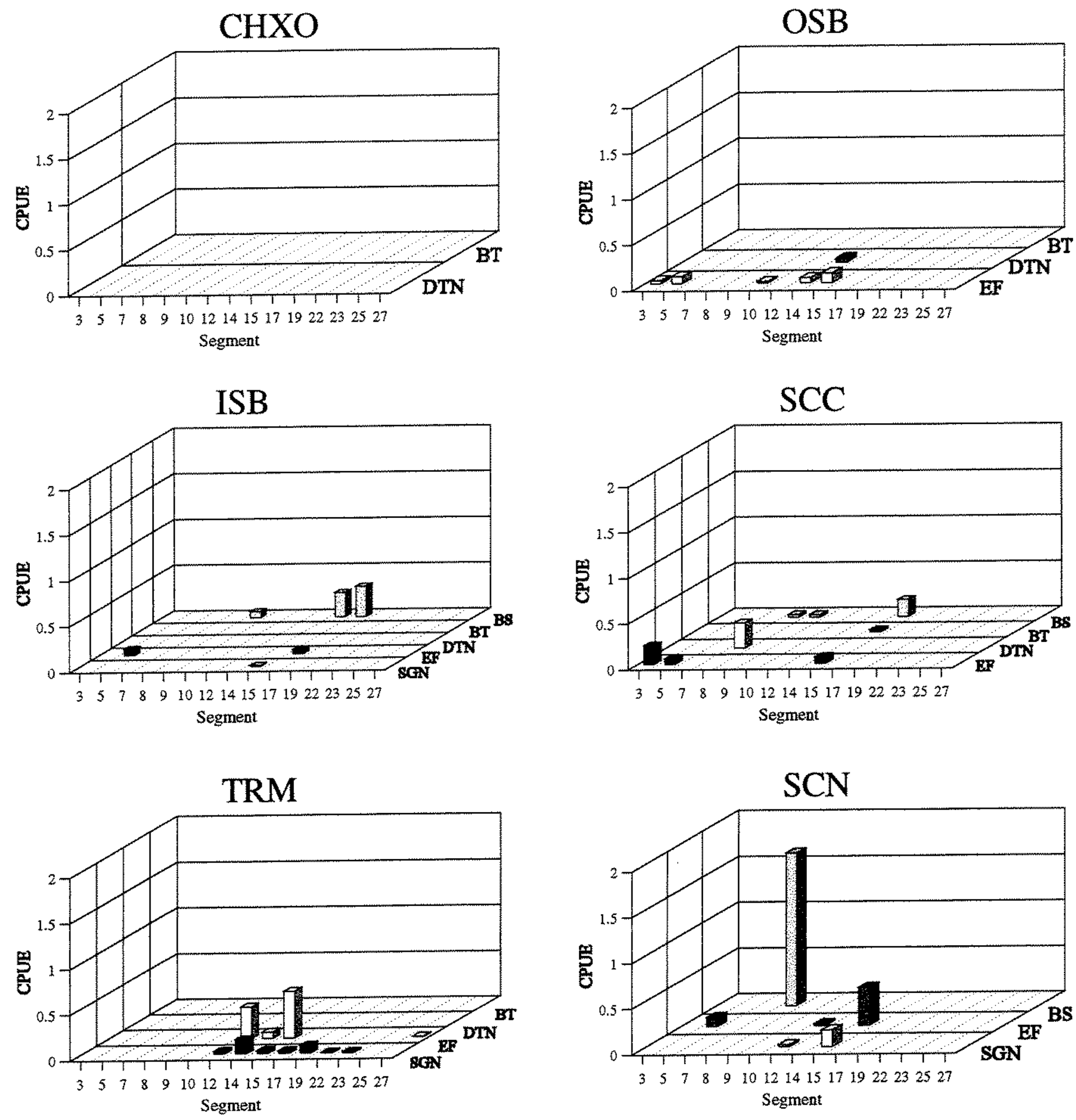
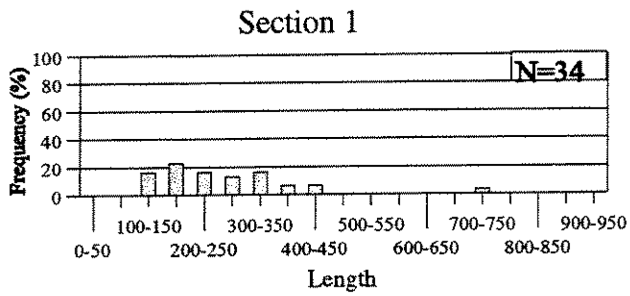
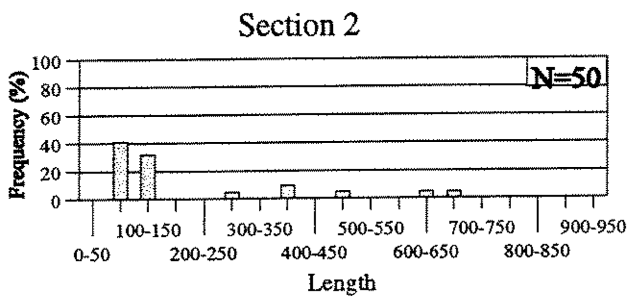
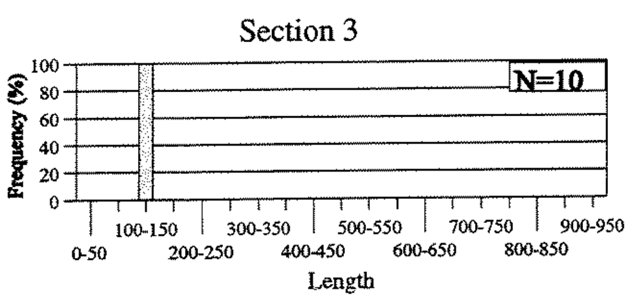


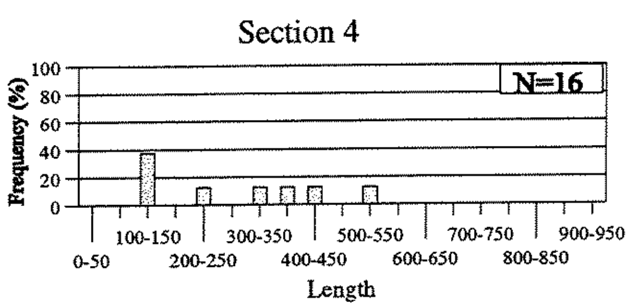
Figure 83. Trends of walleye catch rates among Missouri and Yellowstone River study segments and macrohabitats in 1997. Catch rates are reported as #fish/100m for benthic trawl (BT) and drifting trammel net (DTN), #fish/180 degree haul for a bag seine (BS), #fish/hr for a statinary gill net (SGN), and #fish/min for electrofishing (EF). See Appendix A for list of macrohabitat acronyms.

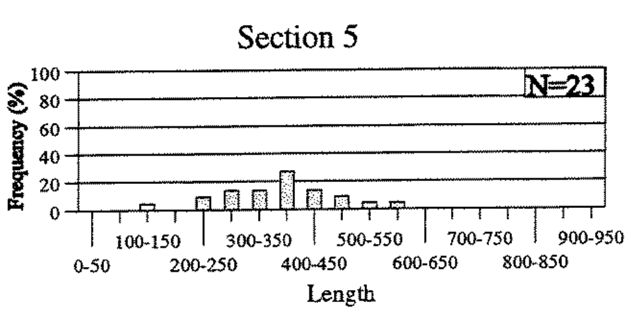
Walleye

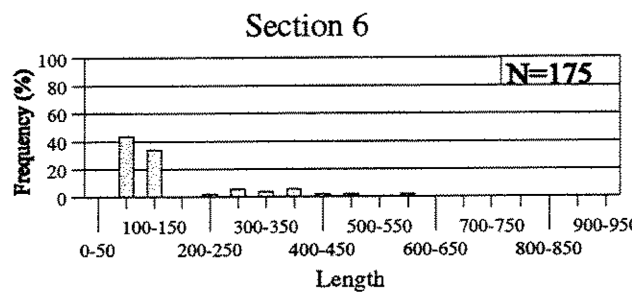


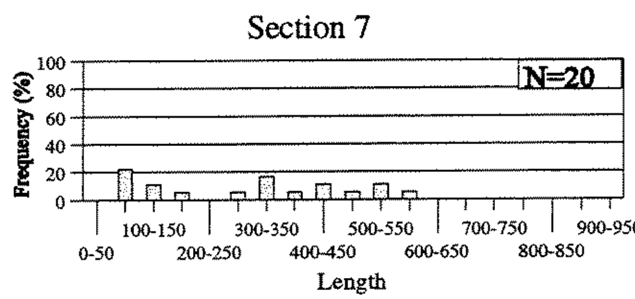


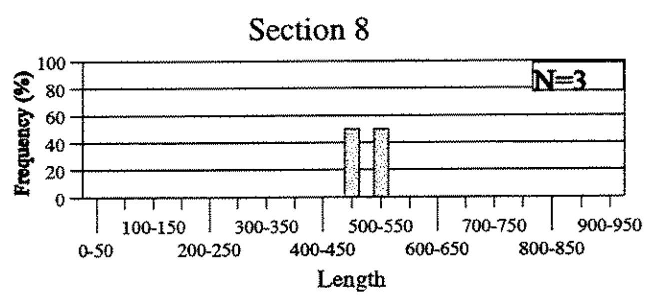












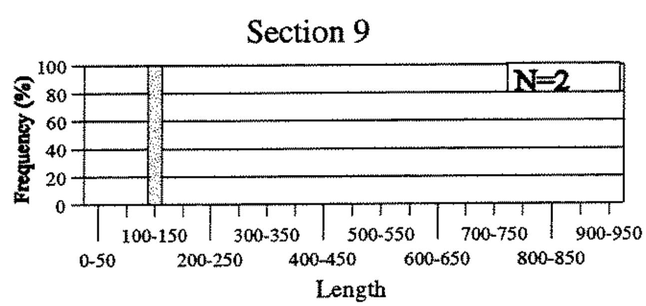
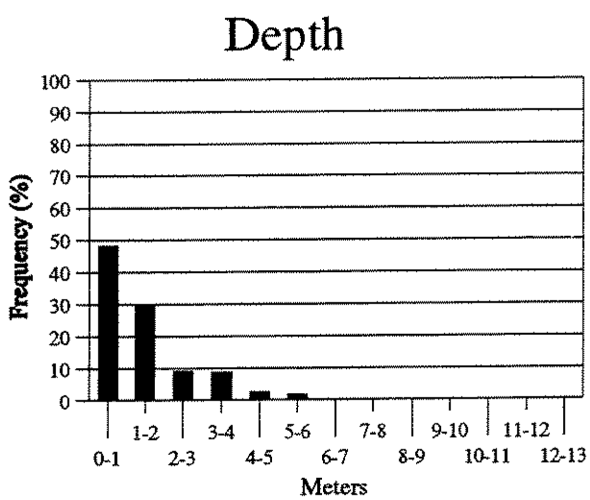
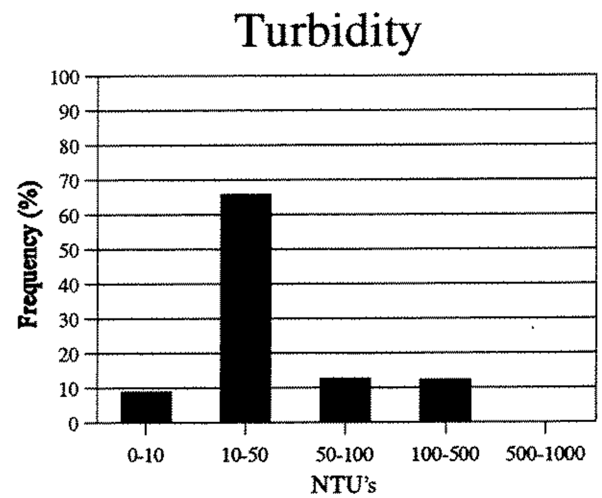
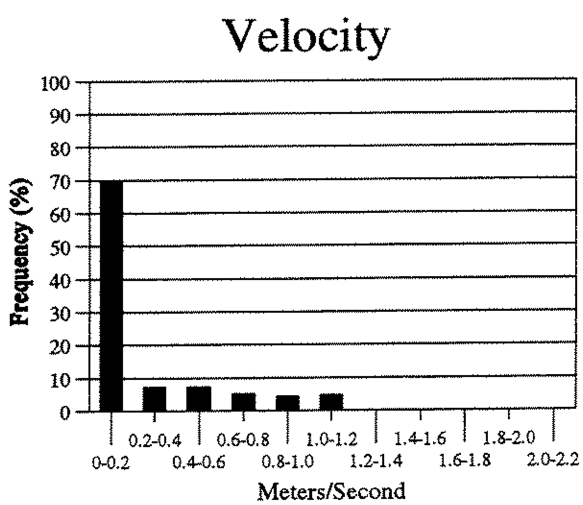


Figure 84. Length-frequency histograms of walleye collected from Missouri and Yellowstone River sections using drifting trammel nets, experimental gill nets, benthic trawls, bag seines, and boat electrofishing. See Table 1 for section definitons.

Walleye







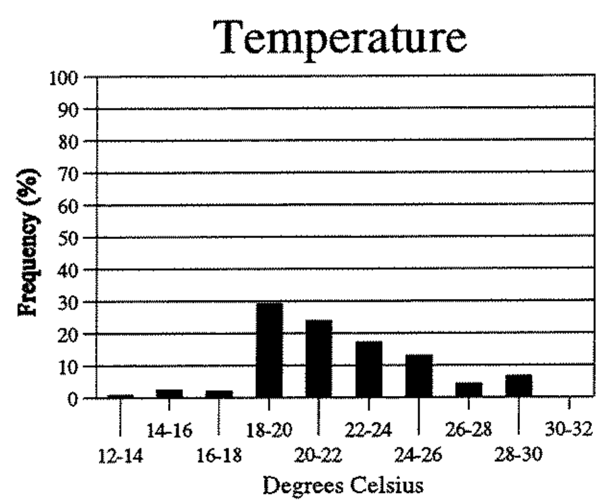


Figure 85. Frequency of occurrence of walleye (N=239) in various depth, velocity, turbidity, and water temperature intervals from Missouri and Yellowstone River collections.

White sucker (WTSK)

A total of 1,208 white suckers was collected; 64% of these fish were taken in segment 12. White suckers were captured in all macrohabitats with all gear types (Figure 86). Highest catch rates were obtained with the bag seine in SCN (Table 33). No white suckers were captured in the channelized segments below Gavins Point Dam.

Most white suckers were captured in shallow (98% in depths < 1 m), clear (90% in turbidities <10 NTUs), and cool waters (76% in temperatures < 18 °C) with low velocities (69% in velocities < 0.2 m/s) (Figure 88). Sixty-four percent of the fish were captured in segment 12, below Garrison Dam, which has no large, sediment bearing tributaries and receives clear, cool water from Garrison Dam's hypolimnetic release.

White suckers were captured in each study section except in section 3 (Yellowstone River) and channelized sections 7, 8, and 9. Sections 2 and 5 had declining length-frequencies with most fish in the 0-50 mm and 50-100 mm length categories (Figure 87). The remaining three sections (sections 1, 4, 6) in which white suckers were captured had fish from only one length category.

White Sucker

Table 33. Catch-Per-Unit-Effort (CPUE) for white sucker by gear, across macrohabitats (CHXO=Channel Cross-Over, ISB=Inside Bend, OSB=Outside Bend, SCC=Secondary Channel Connected, SCN=Secondary Channel Non-Connected, and TRM=Tributary Mouth). Catch rates are reported as #fish/100m for benthic trawl (BT) and drifting trammel net (DTN), #fish/180 degree haul for a bag seine (BS), #fish/hr for a stationary gill net (SGN), and #fish/min for electrofishing (EF). Least-impacted segment numbers = standard font. Inter-reservoir segment numbers = bold font. Channelized segment numbers = italic font. A "-" indicates that no sample was taken.

Segment	CHXO		ISB					OSB			SCC				SCN			TRM			
	BT	DTN	BS	BT	DTN	EF	SGN	BT	DTN	EF	BS	BT	DTN	EF	BS	EF	SGN	BT	DTN	EF	SGN
3	-	0.00	-	-	0.00	0.00	-	-	0.00	0.00	-	-	0.00	0.00	-	-	0.00	-	-	-	-
5	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.00	0.01	-	0.00	0.00	-	-	-	-
7	0.02	0.11	2.08	0.00	0.02	-	-	0.00	0.00	-	0.94	0.00	0.02	-	1.44	-	0.00	-	-	-	0.00
8	0.00	0.00	0.11	0.00	0.00	-	-	0.00	0.00	-	1.15	0.00	0.00	-	0.56	-	-	-	-	-	-
9	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00	-	0.00	0.00	0.00	-	0.00	-	-	-	-	-	-
10	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	0.01	0.00	0.00	0.00	0.00	-
12	0.00	0.07	3.08	0.07	0.30	-	-	0.00	0.00	0.04	18.1	-	-	-	205	0.24	0.02	-	-	0.00	0.00
14	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	0.00	0.00	-	-	0.01	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	-	-	-	-	-	-	-	0.00	0.00
19	0.00	0.00	-	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	0.00	-	-	-	-	0.00	0.00	0.00
22	0.00	0.00	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	-	0.00	0.00	0.00	0.00
25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	-	0.00	0.00	0.00	0.00
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00

White Sucker

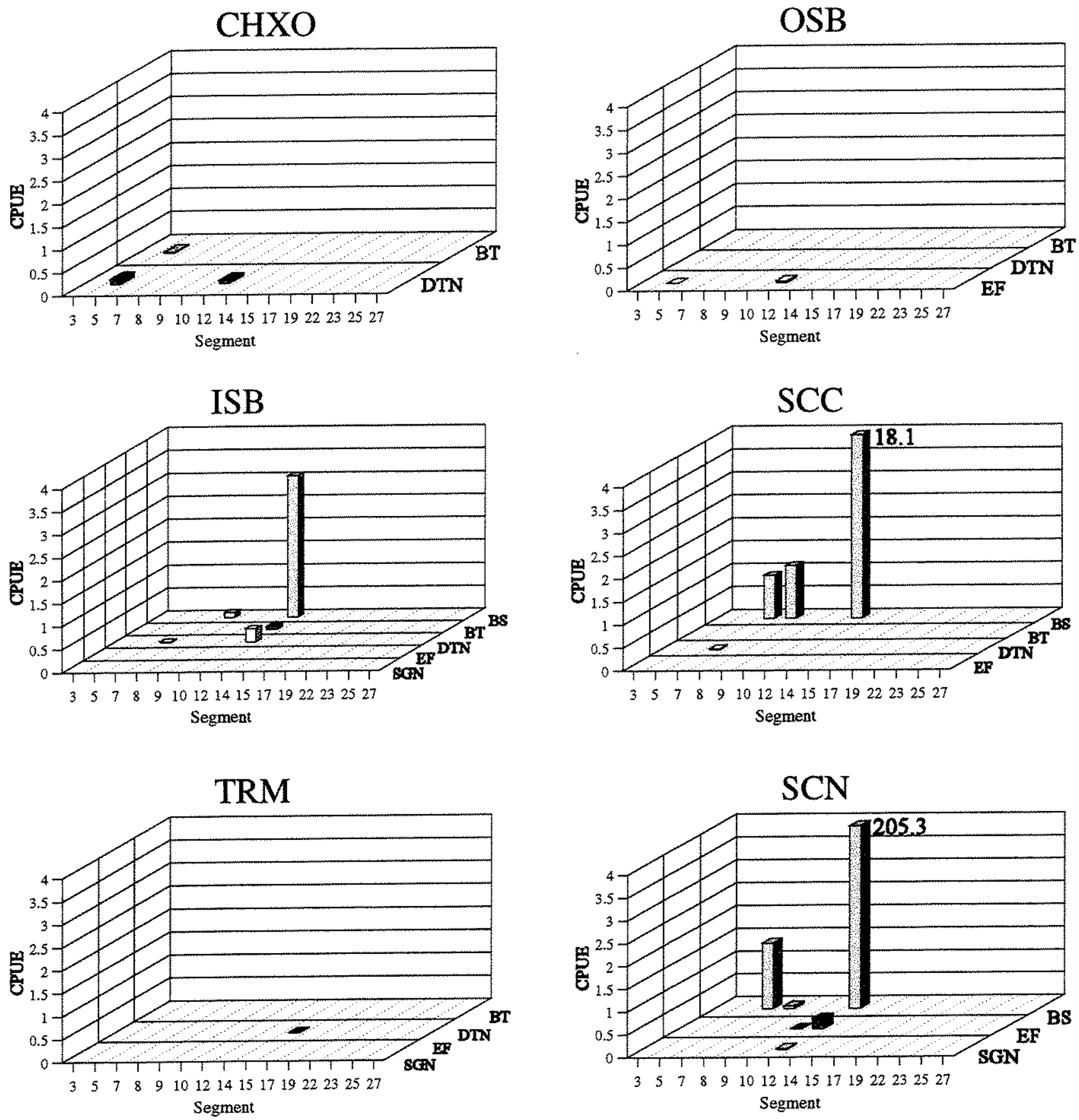
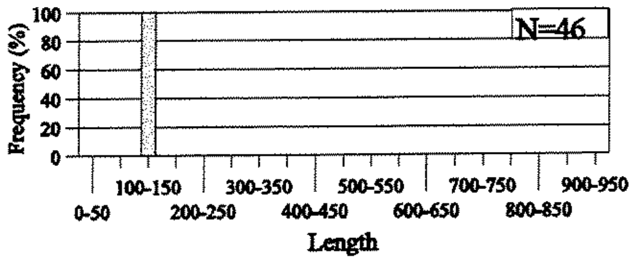


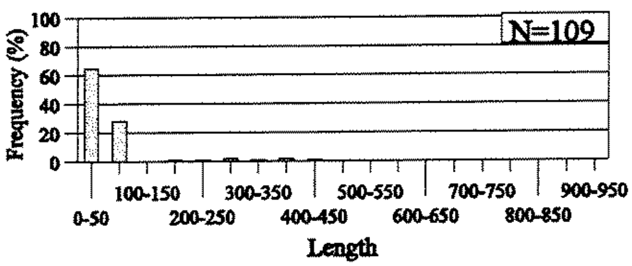
Figure 86. Trends of white sucker catch rates among Missouri and Yellowstone River study segments and macrohabitats in 1997. Catch rates are reported as #fish/100m for benthic trawl (BT) and drifting trammel net (DTN), #fish/180 degree haul for a bag seine (BS), #fish/hr for a statinary gill net (SGN), and #fish/min for electrofishing (EF). See Appendix A for list of macrohabitat acronyms.

White Sucker

Section 1



Section 2



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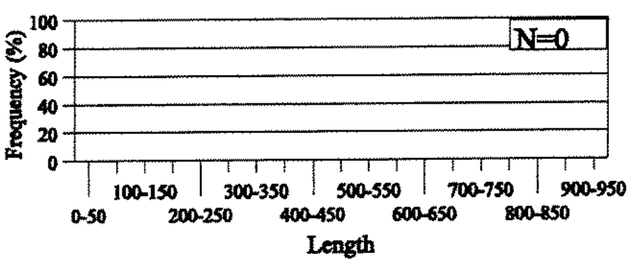

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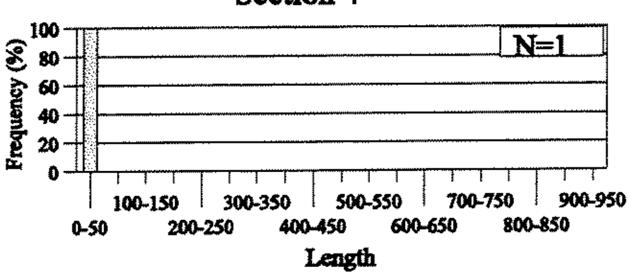

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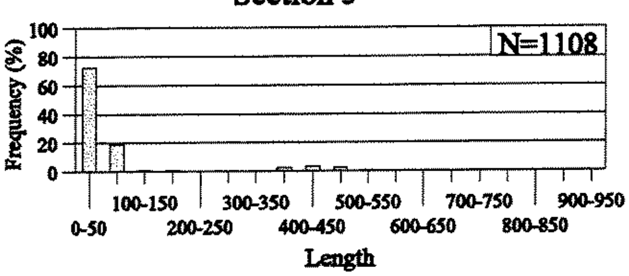

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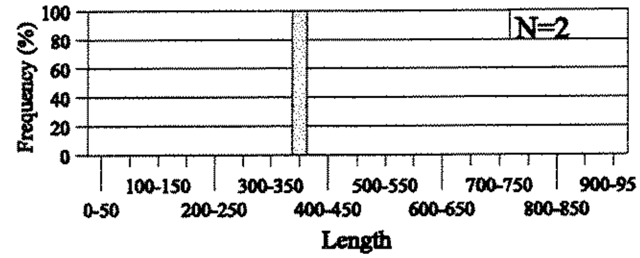

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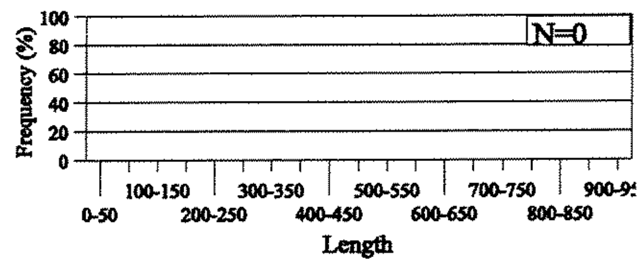

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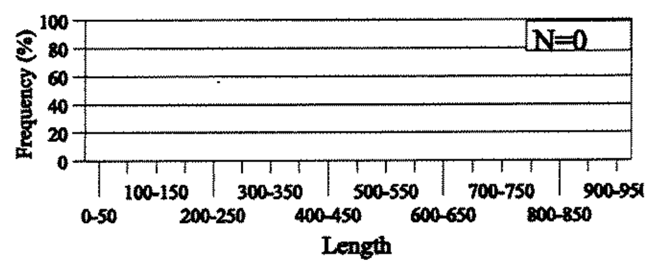


Section 9

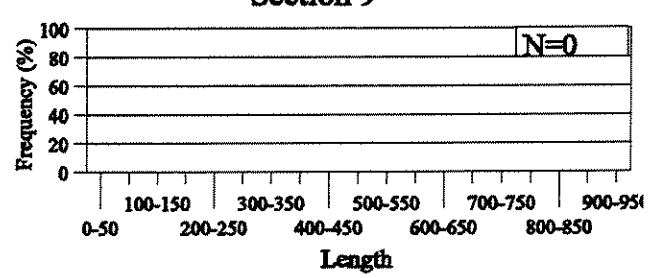


Figure 87. Length-frequency histograms of white sucker collected from Missouri and Yellowstone River sections using drifting trammel nets, experimental gill nets, benthic trawls, bag seines, and boat electrofishing. See Table 1 for section definitons.

White Sucker

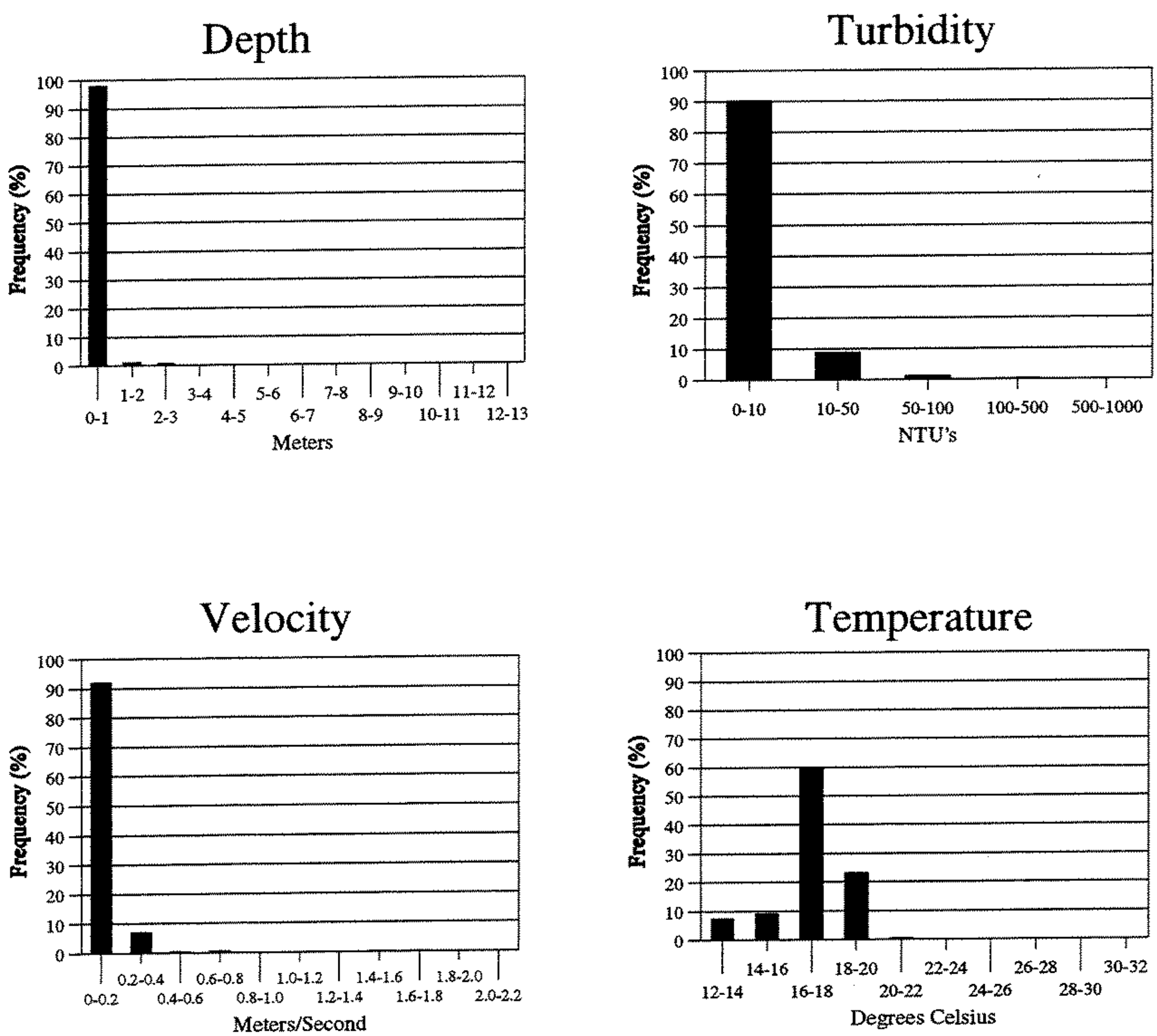


Figure 88. Frequency of occurrence of white sucker (N=1208) in various depth, velocity, turbidity, and water temperature intervals from Missouri and Yellowstone River collections.

Target Benthic Taxa - Discussion

Distribution

More individuals of many species were captured in 1997 as compared to 1996 [14,409 target benthic fish (25,692 total fish) collected in 1996; 31,106 target benthic fish (56,186 total fish) collected in 1997]. The increase in catch for many species can be attributed to increased sampling effort (e.g., gill net sets were changed from 3 h to 12-18 h, electrofishing runs were increased from 5 min to 10 min, the number of gear subsamples in many macrohabitats was increased from 2 to 3). The increase in catch will allow meaningful statistical comparisons of fish data among segments and macrohabitats. These comparisons will be included in the Missouri River Benthic Fish Study final report which has a projected completion date of 1999.

As in 1996, 15 taxa were collected throughout the Missouri and Yellowstone rivers; river carpsucker, shorthead redhorse, smallmouth buffalo, blue sucker, channel catfish, walleye, sauger, common carp, emerald shiner, flathead chub, *Hybognathus spp.*, sicklefin chub, sturgeon chub, shovelnose sturgeon, and freshwater drum. Distribution patterns based on catch rates differed by river zones. In the least-impacted zone, five species were most common: flathead chub, sturgeon chub, sicklefin chub, stonecat, and burbot. In the channelized zone the most common species were river carpsucker, channel catfish, flathead catfish, blue catfish, freshwater drum, blue sucker, emerald shiner, and *Hybognathus* spp. were most common in channelized segments. Blue catfish were captured only in the channelized portion of the river. No benthic fishes were found only in the inter-reservoir segments, but all species except blue catfish were found in one or more inter-reservoir segments. As stated by Dieterman et al. (1996), all benthic species have had a historic range that included five or six states and their current presence or absence in some state may reflect; 1) historic rarity, 2) environmental changes (e.g., an increase in depth and velocity in some segments), 3) sampling bias (e.g., some species may be captured more readily outside of the MRBFC sampling period), and 4) low sampling effort.

Habitat Use

Physical habitat and macrohabitat use was given for 23 taxa in this report. Patterns of macrohabitat use by target taxa were highly variable. Highest catch rates were obtained for seven taxa (white sucker, walleye, sauger, smallmouth buffalo, bigmouth buffalo, common carp, fathead minnow) in SCN, six taxa in ISB (shorthead redhorse, blue catfish, blue sucker, emerald shiner, sicklefin chub, shovelnose sturgeon), six taxa in SCC (river carpsucker, channel catfish, burbot, *Hybognathus spp.*, sturgeon chub, sand shiner), one taxon in OSB (stonecat), and one taxon in TRM (freshwater drum). Highest catch rates were not obtained for any taxa in CHXO, however, species such as sturgeon chub were commonly captured in this macrohabitat.

General macrohabitat use patterns can be interpreted, in part, for some species by examining physical habitat characteristics for macrohabitats in particular segments. Individual species that were distributed throughout much of the Missouri River tended to use macrohabitats with similar physical habitat characteristics. For example, sicklefin and sturgeon chubs were commonly captured in ISB in least impacted and inter-reservoir segments (segments <u>5</u>, **8**, <u>9</u>, **10**) in the upper Missouri River and in channelized segments (segments *22*, *23*, *25*, *27*) in the lower Missouri River. Average current velocities (0.41-0.79 m/s) and depths (1.54-4.64 m) for this macrohabitat were very similar between segments. Similarly, smallmouth buffalo were commonly captured in SCN in least impacted and inter-reservoir segments and in TRM in channelized segments. These two macrohabitats also exhibited similar depths and current velocities.

Patterns of habitat use for benthic fishes in the Missouri and Lower Yellowstone rivers may reflect evolutionary adaptations to the habitat conditions (shallow depths and moderate velocities), sampling biases, gear capture efficiencies, and availability of specific micro- and macrohabitats (Dieterman et al. 1996).

Size Structure

We will not statistically evaluate size structure distributions of fishes until the three years of collection are complete. Size structure improved for many species in 1997, such as river carpsucker, shorthead redhorse, smallmouth buffalo, bigmouth buffalo, blue sucker, stonecat, and walleye. The increase in sampling effort and the addition of gears to various macrohabitats (e.g., electrofishing added to SCN) probably improved capture of a large range of sizes for the species mentioned above, however, size structure for many species is very similar to that found in 1996. For many species, fish in the smallest size classes (< 100 mm) are absent, or nearly so, from our samples. Reasons for this may include: 1) gear efficiency; 2) sampling bias (sampling is conducted prior to fish reaching a size large enough for recruitment to gears); 3) key micro- or macro-habitats were not sampled; 4) low sampling effort; 5) poor reproduction; 6) patchy distribution.

Physical Habitat Variables

Most target benthic fish were captured in shallow depths (< 2 m) and low current velocities (< 0.6 m/s). Taxa collected from shallow depths and low current velocities were smallmouth buffalo, river carpsucker, bigmouth buffalo, white sucker, shorthead redhorse, channel catfish, flathead catfish, burbot, walleye, sauger, freshwater drum, common carp, emerald shiner, flathead chub, fathead minnow, *Hybognathus spp.*, and sand shiner. Species that tended to be captured in deeper water (> 2 m) with higher current velocities (> 0.6 m/s) were sicklefin chub, sturgeon chub, shovelnose sturgeon, blue sucker, stonecat, and blue catfish.

Most species tended to use low to intermediate turbidities (0-100 NTUs). Species with high percentages of individuals captured outside this range (> 100 NTUs) were stonecat, flathead chub, shovelnose sturgeon, and sand shiner. Greater than 20% of stonecats were captured in water greater than 500 NTUs. Water temperature use patterns were highly variable. Most species were captured in water temperatures greater than 20°C. However, individuals of several species were most commonly captured in cool water (< 20°C), such as white sucker, burbot, flathead chub, fathead minnow, and sturgeon chub. The use of cool water temperatures by these species is probably linked to their capture in upper Missouri River or inter-reservoir segments.

Age and Growth - 1996

Mark Pegg, Lisa Coyle, Clay Pierce - Iowa Unit
Pat Braaten, Matt Doeringsfeld, Chris Guy - Kansas Unit

Fish growth is a physiological response to both biotic and abiotic conditions in conjunction with the attained size of the fish from previous growth (Weisberg 1993). Due to this response, age and growth assessment are fundamental in evaluating fish populations. Analyses of this nature have often been used to assess basic life history characteristics such as average growth rates and age at sexual maturation as well as more complex stock assessment models (Ricker 1975; Carlander 1987). Calcified body tissues (scales, otoliths, rays, and spines) can be used to calculate a ratio of the size of hard tissues to actual body length. This ratio is then used as an indicator of growth or growth rate (Casselman 1990).

Calcified body structures were removed from 14 species (Table 34) for age and growth determination in 1996 following Standardized Operating Procedures (Sappington et al. 1997). The selection of which species-specific body structures to use was made from literature reviews when possible or from experimentation prior to collection in 1996. Most species used for this analysis represented the benthic fish community present throughout the Missouri and lower Yellowstone rivers. However, sicklefin chubs, flathead chubs, and *Hybognathus spp.* were included because these taxa are presumed to be in decline and require immediate attention.

The format for this section will include a summary of the growth results along with figures of age distribution and mean back-calculated lengths at age by zone (least-impacted, inter-reservoir, and channelized) for each species. Comparisons of length at age among the zones were made only on specific year-classes because low sample sizes for many of the target species can bias back-calculation estimates (Lee's phenomenon; DeVries and Frie 1996), and both age and environmental conditions across year-classes can influence overall growth rate estimates. Differences in lengths at age among the zones were tested using analysis of variance (ANOVA) at the $P \leq 0.05$ level. Estimated lengths are influenced by the previous year(s) growth, even within a specific year-class, which prevents comparisons after age-1 from being strictly independent. Therefore, analyses were further limited to age-1 and the oldest age possible within each age class. The test at the older age is not independent of the age-1 test, but is presumed to be primarily influenced by growth after age-1, and is a "reasonably" unbiased comparison of growth after age-1. Individuals of the same year-class were not collected from all three zones for several species and were not used for comparisons of back-calculated length at age.

Table 34. Missouri River benthic fish species used for age and growth analysis. Each structure is identified as the primary ([a]) or secondary ([b]) structure used for age determination. Primary body structures were used exclusively for back-calculation.

Species	Body Structure		Responsible Unit
Flathead chub *Platygobio gracilis*	scale[a]	otolith[b]	Iowa
Sicklefin chub *Macrhybopsis meeki*	scale[a]	otolith[b]	Kansas
Sand shiner *Notropis stramineus*	scale[a]	otolith[b]	Kansas
Emerald shiner *Notropis atherinoides*	scale[a]	otolith[b]	Kansas
W. silvery minnow *Hybognathus argyritis*	scale[a]	otolith[b]	Iowa
Brassy minnow *Hybognathus hankinsoni*	scale[a]	otolith[b]	Iowa
Plains minnow *Hybognathus placitus*	scale[a]	otolith[b]	Iowa
Blue sucker *Cycleptus elongatus*	scale[a]	fin ray[b]	Kansas
River carpsucker *Carpiodes carpio*	scale[a]	fin ray[b]	Kansas
Smallmouth buffalo *Ictiobus bubalus*	scale[a]	fin ray[b]	Iowa
Freshwater drum *Aplodinotus grunniens*	scale[b]	otolith[a]	Kansas
Sauger *Stizostedion canadense*	scale[b]	otolith[a]	Kansas
Channel catfish *Ictalurus punctatus*	pectoral spine[a]		Iowa
Flathead catfish* *Pylodictis olivaris*	pectoral spine[a]		Kansas
Shovelnose sturgeon *Scaphirynchus platyorynchus*	pectoral fin ray[a]		Iowa

*Flathead catfish added as age and growth species in 1997.

Blue Sucker

Forty-three blue suckers were used for age and growth analysis. Maximum ages varied from age-8 in the channelized zone to age-10 in the least-impacted zone. All individuals collected in the least-impacted zone were greater than age-6, while most age groups were represented in the inter-reservoir and channelized zones (Figure 89). A lack of individuals of the same year-class present in all three zones prevented age-specific analysis of mean back-calculated length.

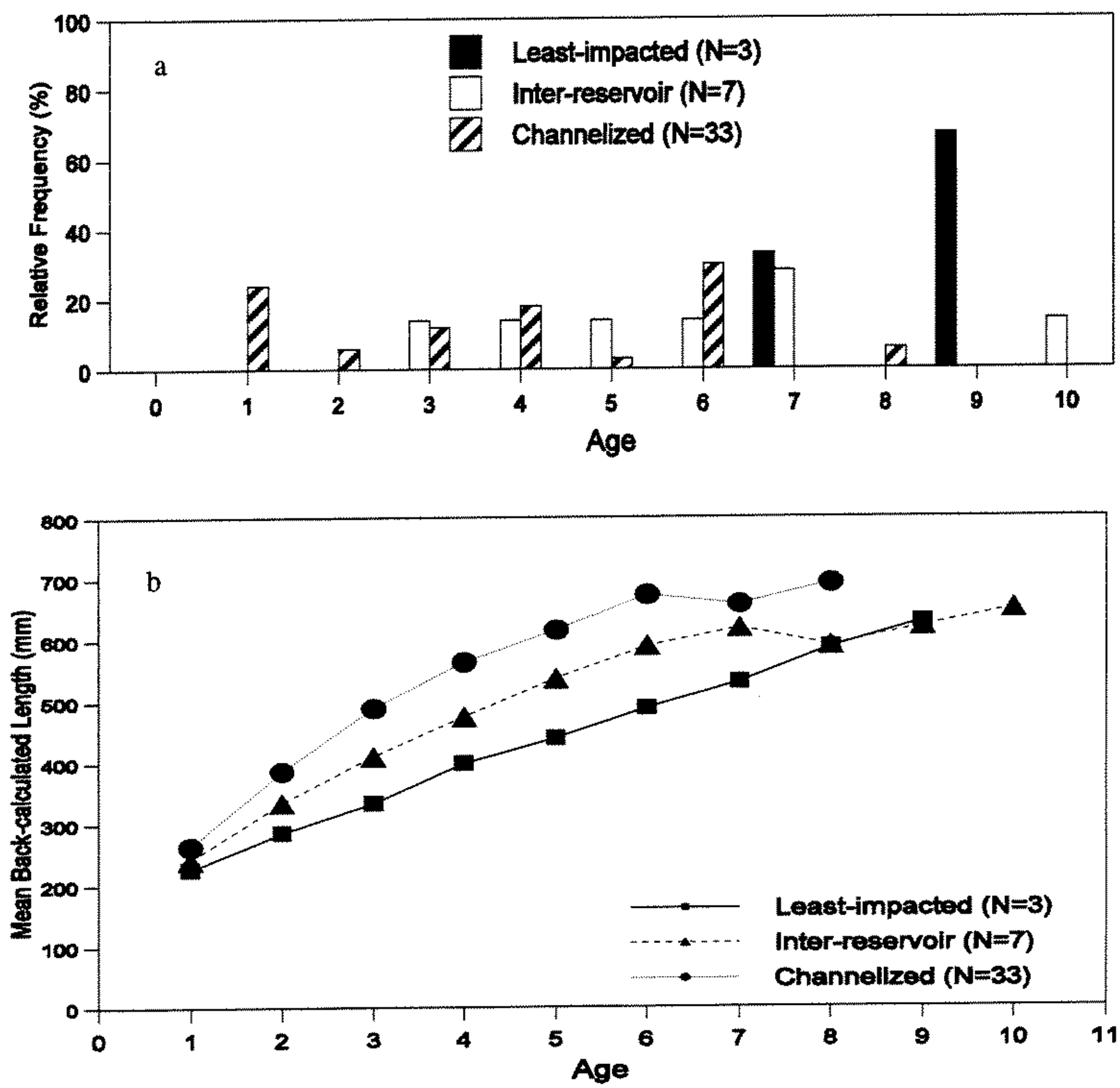


Figure 89. Age frequency distribution (a) and mean back-calculated lengths at age (b) for blue suckers collected in 1996.

Channel Catfish

A total of 493 channel catfish were analyzed. Maximum ages varied from 8 to 11 years among the three zones. Age frequencies were skewed toward older fish in the least-impacted zone and toward younger fish in the channelized zone; whereas, age-classes were more evenly distributed in the inter-reservoir zone (Figure 90). Mean back-calculated lengths at age suggest a slower growth rate for the inter-reservoir zone compared to the other zones of the Missouri River (Figure 90). Specific comparisons of estimated lengths for the 1991 year-class support this conclusion (Table 35).

Table 35. Analysis of variance comparisons of mean back-calculated lengths for the 1991 year-class of channel catfish among three Missouri River zones. Similar letters indicate no difference among means for each age (differences declared at the $P \leq 0.05$ level). Standard errors for each mean length estimate are listed in parentheses.

	Mean Back-calculated Length (mm)		
Age	Least-Impacted (N = 5)	Inter-Reservoir (N = 22)	Channelized (N = 13)
1	71[a] (12.7)	43[b] (1.4)	70[a] (9.7)
2	122 (18.9)	77 (3.5)	147 (17.0)
3	184 (16.3)	137 (5.3)	264 (16.4)
4	272 (12.9)	209 (4.8)	313 (21.3)
5	322[a] (14.0)	265[b] (3.9)	376[c] (20.2)

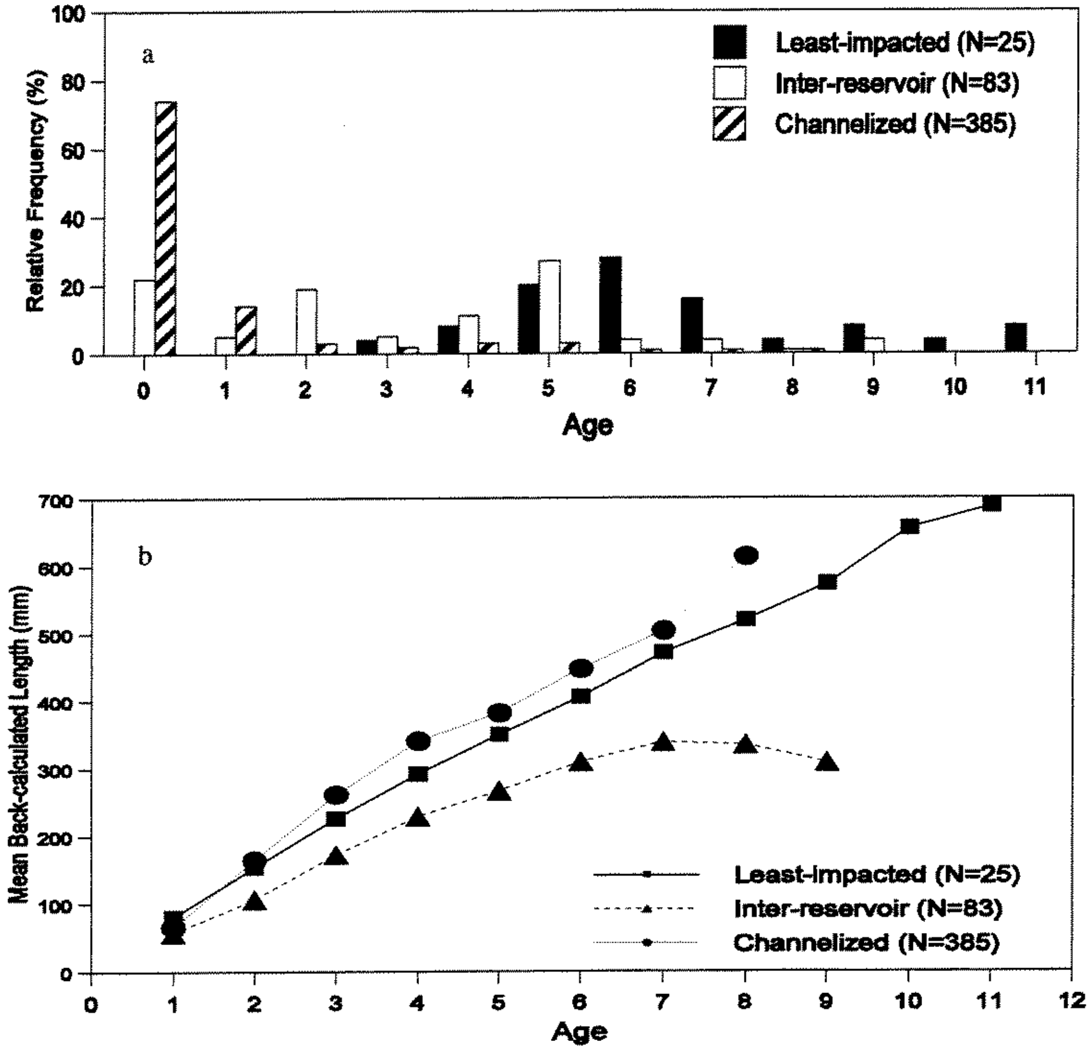


Figure 90. Age frequency distribution (a) and mean back-calculated length at age (b) for channel catfish collected in 1996.

Emerald Shiner

A total of 1,016 emerald shiners were used for age and growth analysis. Emerald shiners up to age-2 were collected in all three zones. The age distribution for both the inter-reservoir and channelized zones were skewed toward young-of-year fish (Figure 91). Conversely, age-1 fish were most prevalent in the least-impacted zone. Growth rates of emerald shiners were comparable among the three zones and age-specific analysis of the 1995 year-class show no significant differences among zones (Table 36).

Table 36. Analysis of variance comparisons of mean back-calculated lengths for the 1995 year-class of emerald shiners among three Missouri River zones. Similar letters indicate no difference among means (differences declared at the $P \leq 0.05$ level). Standard errors for each mean length estimate are listed in parentheses.

	Mean Back-calculated Length (mm)		
Age	Least-Impacted (N = 126)	Inter-Reservoir (N = 33)	Channelized (N = 10)
1	51[a] (0.7)	53[a] (1.3)	51[a] (3.2)

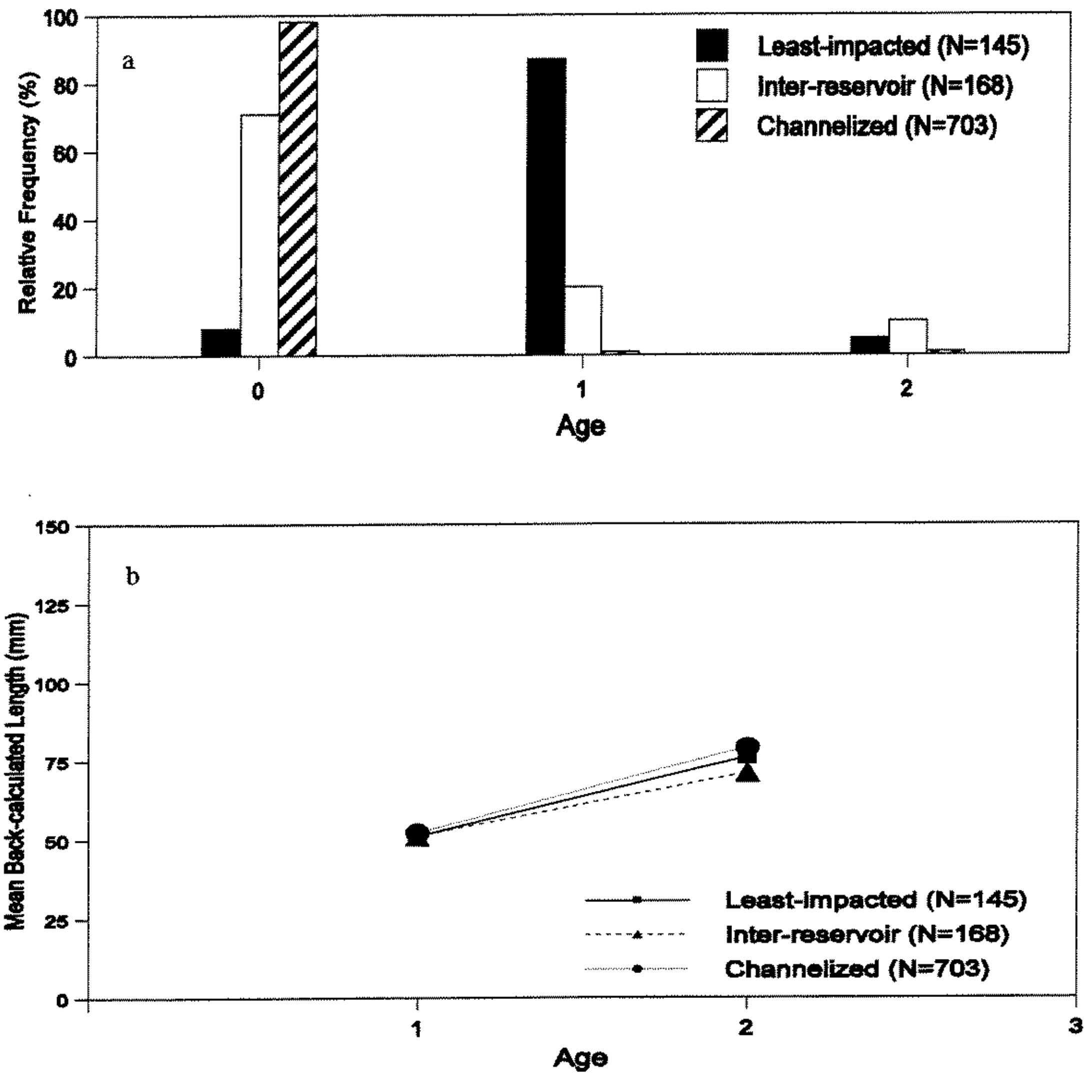


Figure 91. Age frequency distribution (a) and mean back-calculated length at age (b) for emerald shiners collected in 1996.

Flathead Chub

Three hundred eighty-six flathead chubs were used for age and growth purposes. Nearly all flathead chubs (98%) collected in 1996 were taken from the least-impacted and inter-reservoir zones. Maximum ages varied from age-1 in the channelized zone to age-7 in the least-impacted zone. However, the age distribution along the entire river was dominated by age-0 individuals (Figure 92). Comparisons of the 1995 year-class among zones are somewhat different than the overall mean back-calculated lengths shown in Figure 92 (Table 37).

Table 37. Analysis of variance comparisons of mean back-calculated lengths for the 1995 year-class of flathead chubs among three Missouri River zones. Similar letters indicate no difference among means (differences declared at the $P \leq 0.05$ level). Standard errors for each mean length estimate are listed in parentheses.

	Mean Back-calculated Length (mm)		
Age	Least-Impacted (N = 36)	Inter-Reservoir (N = 1)	Channelized (N = 1)
1	74^{a} (1.1)	97^{b}	56^{c}

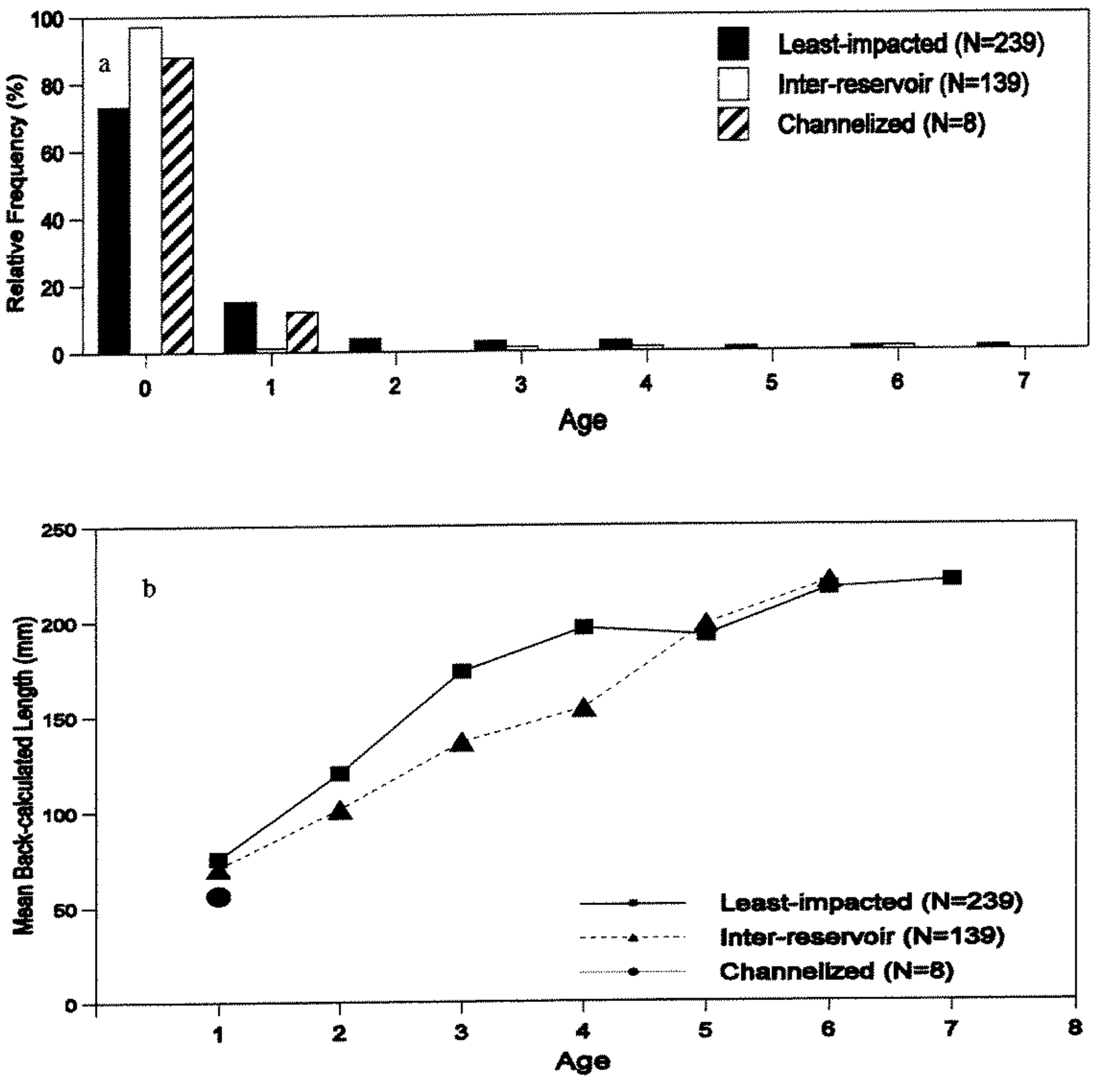


Figure 92. Age frequency distribution (a) and mean back-calculated length at age (b) for flathead chubs collected in 1996.

Freshwater Drum

Maximum ages of the 334 freshwater drum collected in 1996 varied from age-5 in the inter-reservoir zone to age-22 in the least-impacted zone. The majority of freshwater drum aged were ≤ age-5 (Figure 93). Age-specific analysis of the 1991 year-class indicates that, for most ages, the least-impacted zone had significantly lower mean back-calculated lengths than the other two zones (Table 38). The decline in mean back-calculated lengths between age-8 and age-10 for the least-impacted and channelized zones, in Figure 93, can be attributed to a low sample size of fish over age-8 which likely resulted in Lee's phenomenon.

Table 38. Analysis of variance comparisons of mean back-calculated lengths for the 1991 year-class of freshwater drum among three Missouri River zones. Similar letters indicate no difference among means for each age (differences declared at the $P \leq 0.05$ level). Standard errors for each mean length estimate are listed in parentheses.

	Mean Back-calculated Length (mm)		
Age	Least-Impacted (N = 17)	Inter-Reservoir (N = 7)	Channelized (N = 2)
1	64[a] (2.6)	86[b] (6.2)	72[ab] (12.8)
2	117 (2.6)	170 (7.8)	154 (0.7)
3	169 (2.2)	234 (12.9)	225 (1.0)
4	217 (3.1)	287 (12.8)	280 (1.4)
5	250[a] (4.0)	329[b] (14.9)	332[b] (0.1)

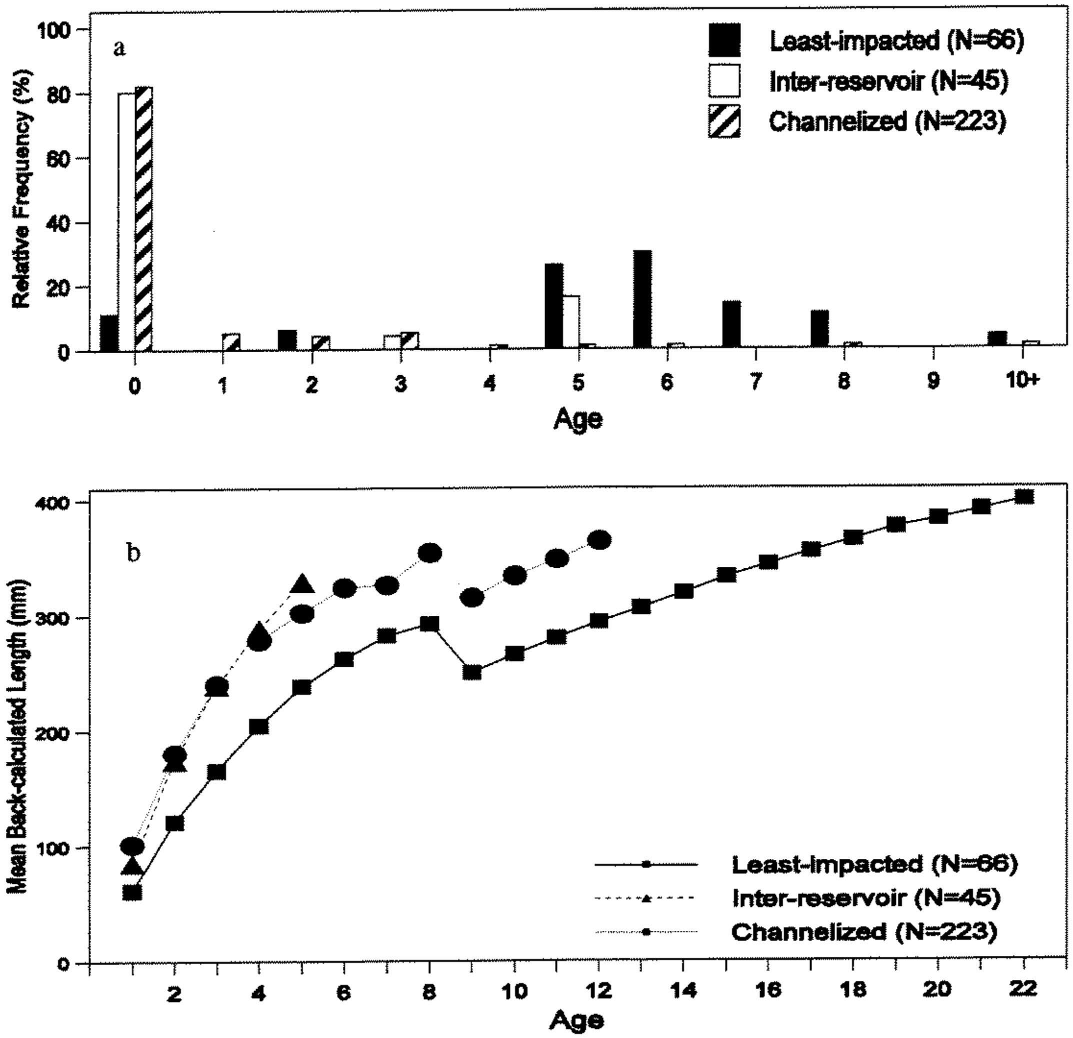


Figure 93. Age frequency distribution (a) and mean back-calculated length at age (b) for freshwater drum collected in 1996.

Hybognathus spp.

Three species of the genus *Hybognathus* (brassy minnow, plains minnow, and western silvery minnow) were selected for age and growth analysis in 1996. The data collected for brassy minnows and plains minnows did not provide sufficient information to allow for river-wide comparisons of mean back-calculated lengths at age because neither of these species were captured in the least-impacted zone. However, age distributions of brassy minnows (N = 44) and plains minnows (N = 190) were fairly similar because age-0 individuals were the most abundant age for both species (Figure 94).

Western silvery minnows (N = 204) were the only species within the genus *Hybognathus* that were caught in enough abundance to provide growth comparisons among all zones. Maximum ages varied from age-1 in the channelized zone to age-4 in the least-impacted zone. Age-0 fish were dominant (> 60%) in both the channelized and inter-reservoir zones (Figure 95). The age distribution of western silvery minnows in the least-impacted zone was fairly balanced through age-2. Direct comparison among the estimated back-calculated lengths at age-1 for the 1995 year-class shows the channelized zone having slower growth than the upstream reaches of the river (Table 39).

Table 39. Analysis of variance comparisons of mean back-calculated lengths for the 1995 year-class of western silvery minnows among three Missouri River zones. Similar letters indicate no difference among means (differences declared at the $P \leq 0.05$ level). Standard errors for each mean length estimate are listed in parentheses.

	Mean Back-calculated Length (mm)		
Age	Least-Impacted (N = 26)	Inter-Reservoir (N = 24)	Channelized (N = 2)
1	58^{a} (0.9)	58^{a} (0.5)	49^{b} (2.2)

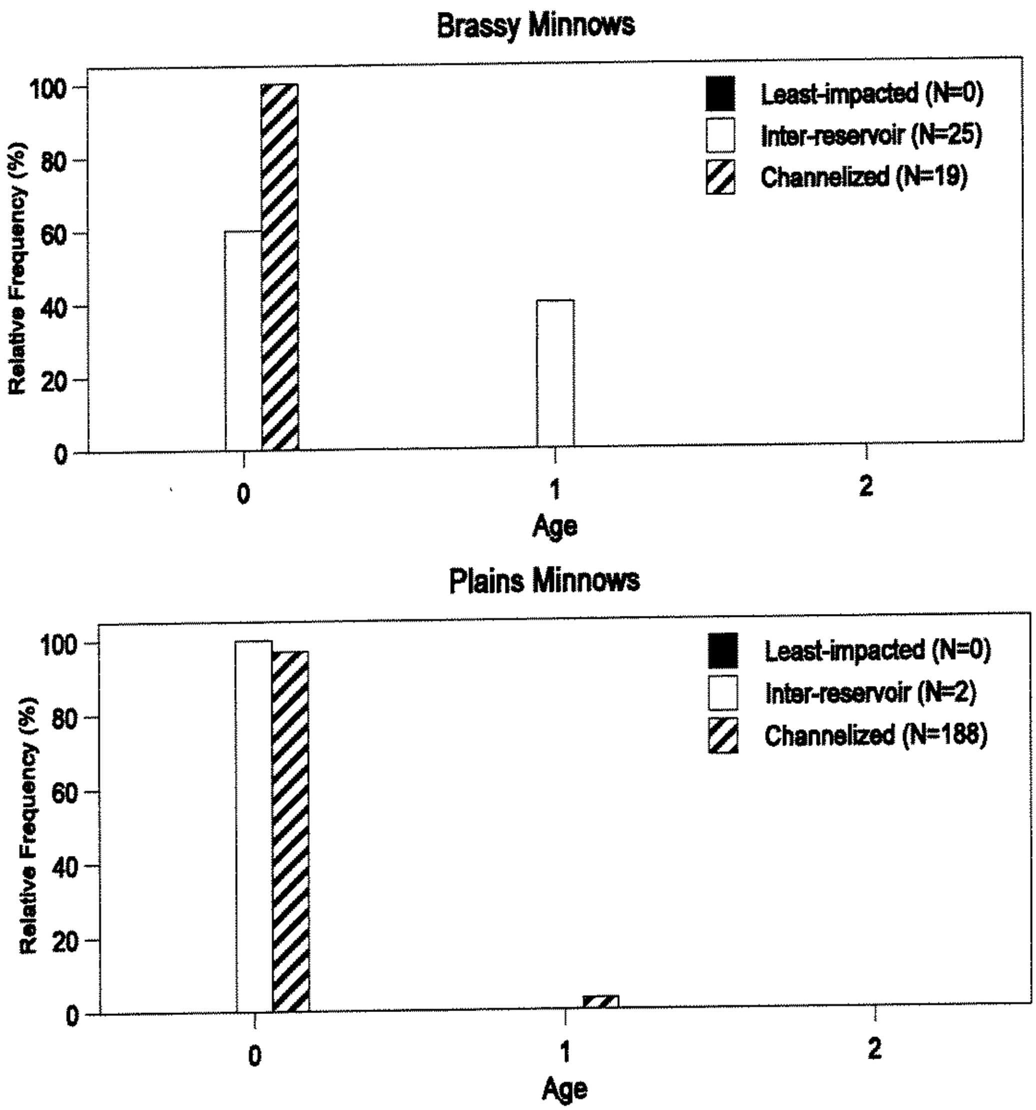


Figure 94. Age frequency distributions for brassy minnows and plains minnows collected in 1996.

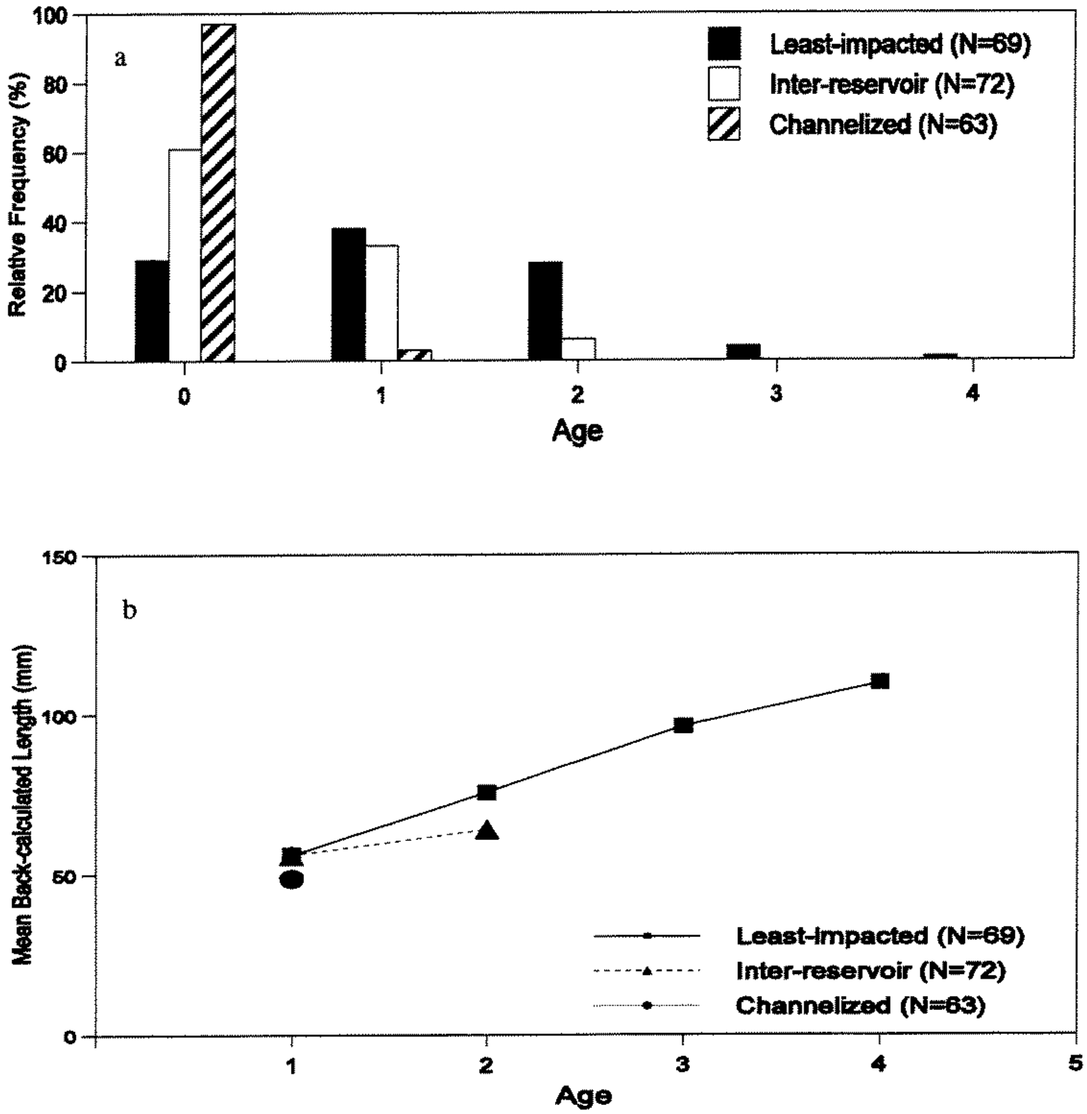


Figure 95. Age frequency distribution (a) and mean back-calculated length at age (b) for western silvery minnows collected in 1996.

River Carpsucker

A total of 391 river carpsuckers were used for age and growth analysis. Maximum ages varied from age-9 in the channelized and inter-reservoir zones to age-11 in the least-impacted zone (Figure 96). Age-specific comparisons of mean back-calculated lengths for the 1991 year-class were significantly different among the three zones at both age-1 and age-5, with the channelized zone having the greatest estimated lengths (Table 40).

Table 40. Analysis of variance comparisons of mean back-calculated lengths for the 1991 year-class of river carpsuckers among three Missouri River zones. Similar letters indicate no difference among means for each age (differences declared at the $P \leq 0.05$ level). Standard errors for each mean length estimate are listed in parentheses.

	Mean Back-calculated Length (mm)		
Age	Least-Impacted (N = 7)	Inter-Reservoir (N = 34)	Channelized (N = 15)
1	64[a] (6.4)	74[a] (3.6)	89[b] (4.8)
2	142 (18.9)	151 (4.9)	155 (8.6)
3	216 (29.6)	227 (6.0)	227 (7.8)
4	275 (30.7)	299 (5.2)	303 (8.2)
5	329[a] (25.2)	356[ab] (4.7)	373[b] (11.3)

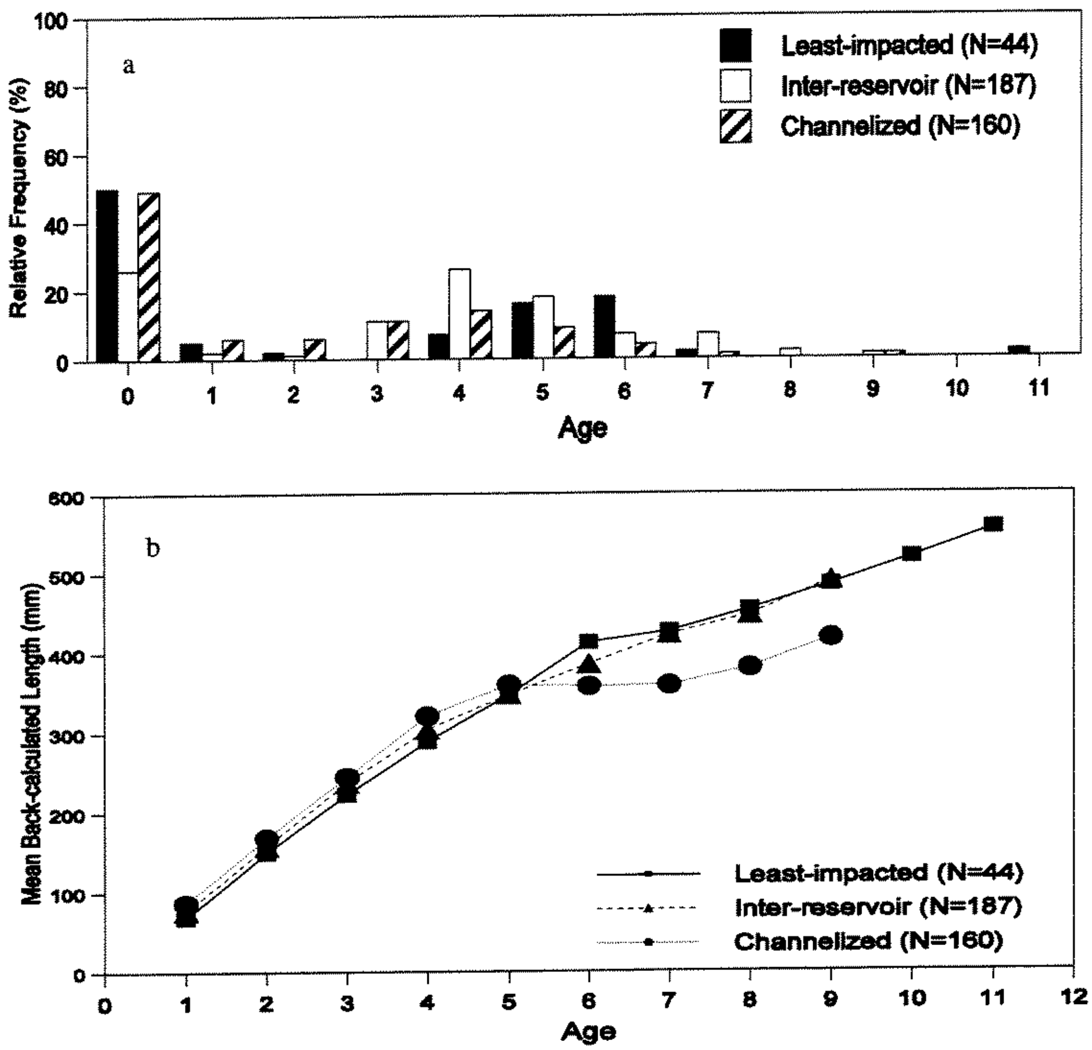


Figure 96. Age frequency distribution (a) and mean back-calculated length at age (b) for river carpsuckers collected in 1996.

Sand Shiner

Few sand shiners were caught throughout the river which prevented any comparisons of mean back-calculated lengths among zones. Of the of 100 individuals collected in 1996, 81% were taken from the inter-reservoir zone below Gavins Point Dam and 19% were from the channelized zone. The channelized zone age distribution consisted entirely of age-0 individuals, while the inter-reservoir zone was comprised of age-0, age-1, and age-2 fish (Figure 97).

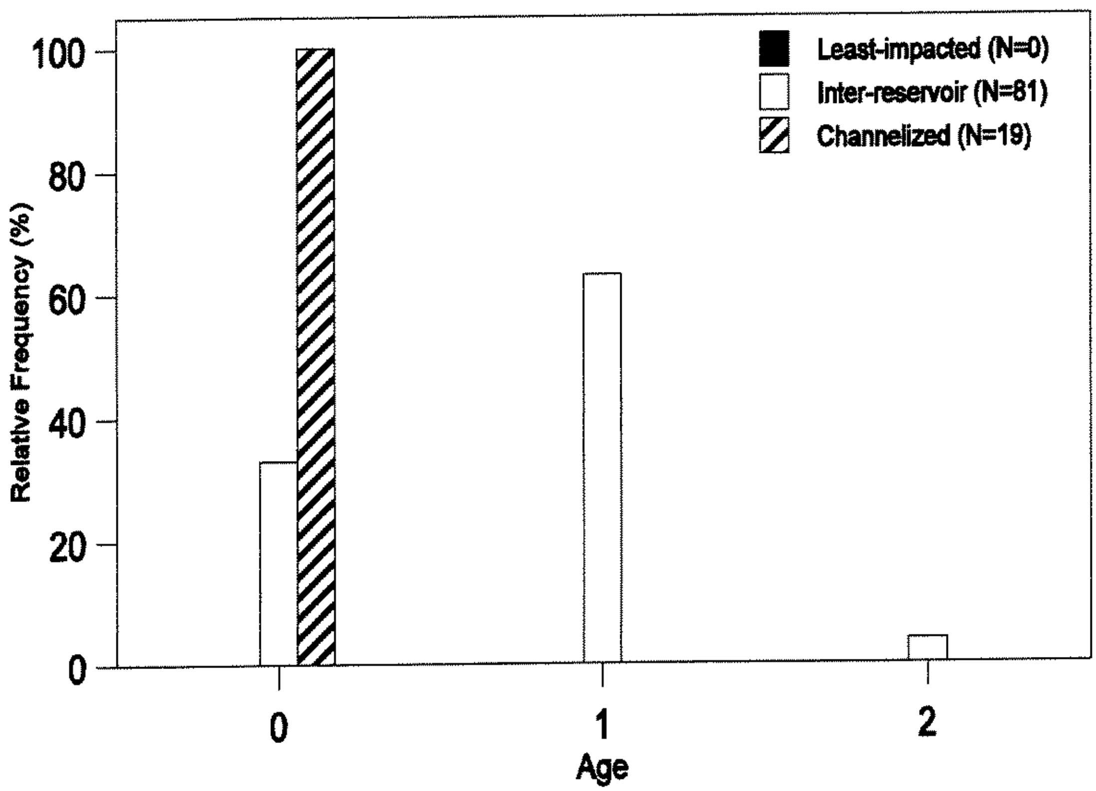


Figure 97. Age frequency distribution for sand shiners collected in 1996.

Sauger

Maximum ages of the 101 saugers aged in 1996 varied from age-3 in the inter-reservoir zone to age-9 in the least-impacted zone. The age distributions for the three zones were similar; most individuals were ≤ age-3 (Figure 98).

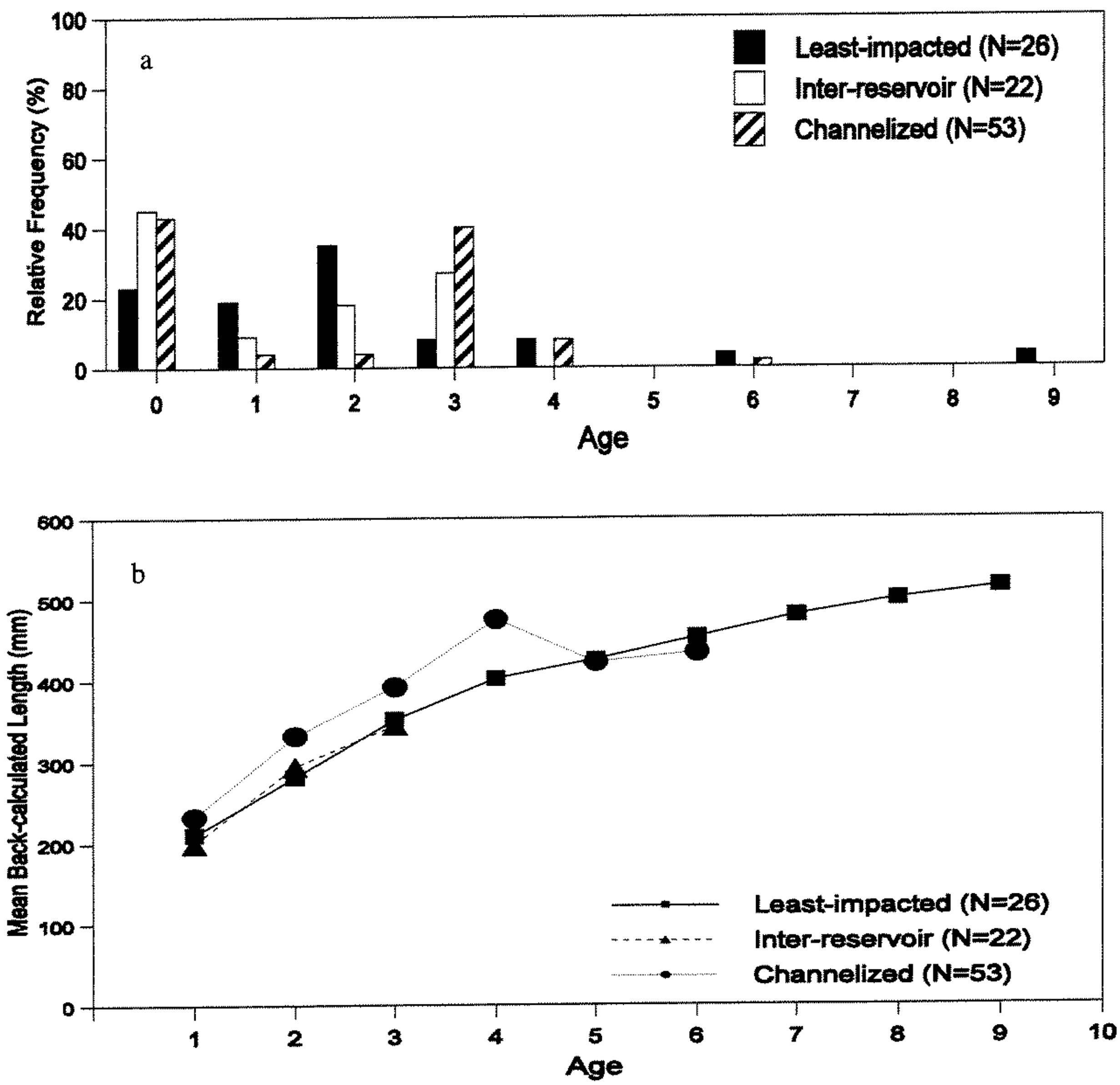


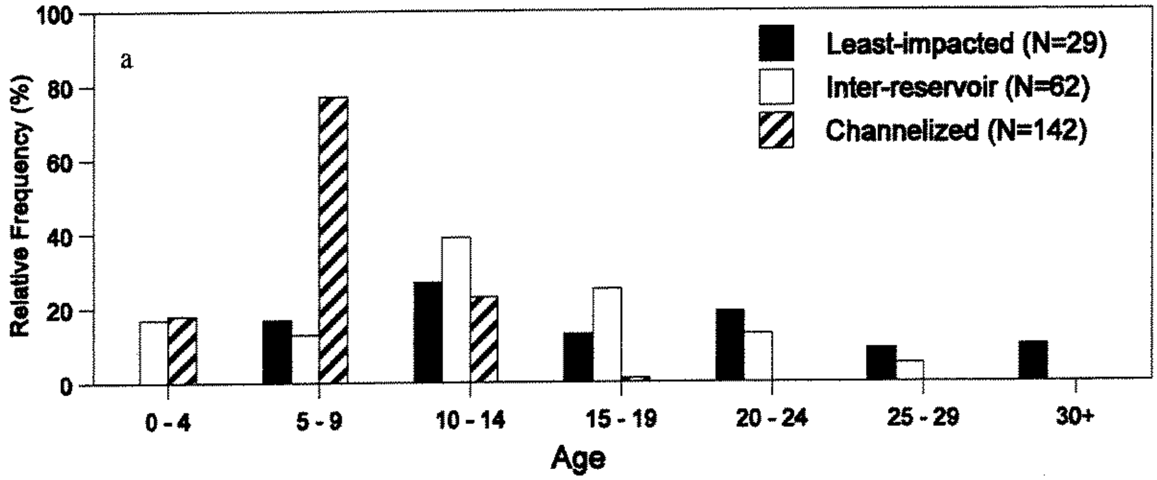
Figure 98. Age frequency distribution (a) and mean back-calculated length at age (b) for sauger collected in 1996.

Shovelnose Sturgeon

A total of 233 shovelnose sturgeon were used for age and growth evaluation. Maximum ages were quite variable for this long-lived species. The least-impacted zone had several individuals over 30 years of age with the oldest being 34. Contrastingly, the oldest individuals captured in the channelized zone were age-15. The age frequency distribution had a fairly large input from the 'intermediate' age-classes of 6 to 15 years (Figure 99). Age-specific comparisons among the 1986 year-class indicate similar length estimates among the zones for the first year of life; whereas, length estimates for the least-impacted and inter-reservoir zones were lower than the channelized zone at age-10 (Table 41).

Table 41. Analysis of variance comparisons of mean back-calculated lengths for the 1986 year-class of shovelnose sturgeon among three Missouri River zones. Similar letters indicate no difference among means for each age (differences declared at the $P \leq 0.05$ level). Standard errors for each mean length estimate are listed in parentheses.

	Mean Back-calculated Length (mm)		
Age	Least-Impacted (N = 2)	Inter-Reservoir (N = 4)	Channelized (N = 15)
1	77[a] (0.3)	107[a] (34.5)	73[a] (7.8)
2	135 (6.3)	173 (33.4)	145 (12.5)
3	198 (7.4)	219 (23.8)	231 (14.2)
4	247 (16.8)	284 (16.7)	293 (15.9)
5	291 (25.6)	338 (16.4)	347 (17.3)
6	341 (14.1)	373 (16.4)	407 (14.5)
7	383 (0.5)	415 (15.0)	449 (14.0)
8	433 (8.7)	445 (12.5)	489 (12.1)
9	473 (32.9)	470 (13.9)	526 (13.1)
10	496[a] (33.1)	505[a] (10.8)	558[b] (11.2)



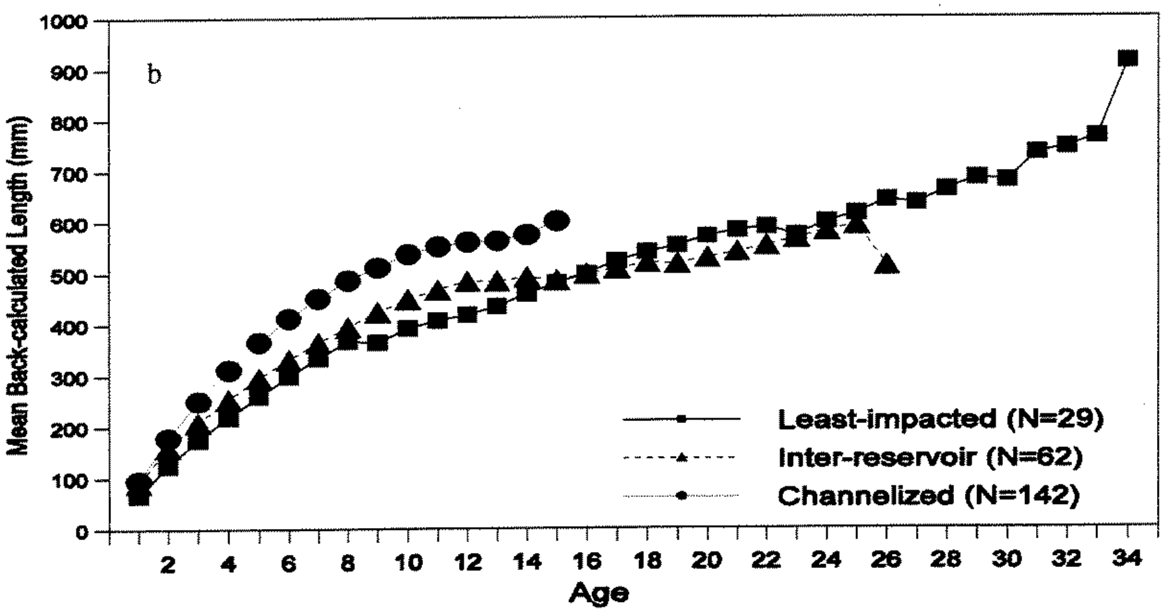


Figure 99. Age frequency distribution (a) and mean back-calculated length at age (b) for shovelnose sturgeon collected in 1996.

Sicklefin Chub

Seventy-three sicklefin chubs were used for age and growth analysis. Maximum age attained was age-2 in all zones. However, the age distributions were variable among zones. For example, no age-0 fish were captured above the channelized zone and nearly all individuals (87%) in the inter-reservoir zone were age-2 (Figure 100). Comparison of mean back-calculated lengths for the 1994 year-class indicate similar growth for all zones and years of life (Table 42).

Table 42. Analysis of variance comparisons of mean back-calculated lengths for the 1994 year-class of sicklefin chubs among three Missouri River zones. Similar letters indicate no difference among means for each age (differences declared at the $P \leq 0.05$ level). Standard errors for each mean length estimate are listed in parentheses.

	Mean Back-calculated Length (mm)		
Age	Least-Impacted (N = 14)	Inter-Reservoir (N = 26)	Channelized (N = 3)
1	38[a] (1.4)	37[a] (0.7)	36[a] (3.2)
2	66[a] (2.6)	65[a] (1.2)	69[a] (10.6)

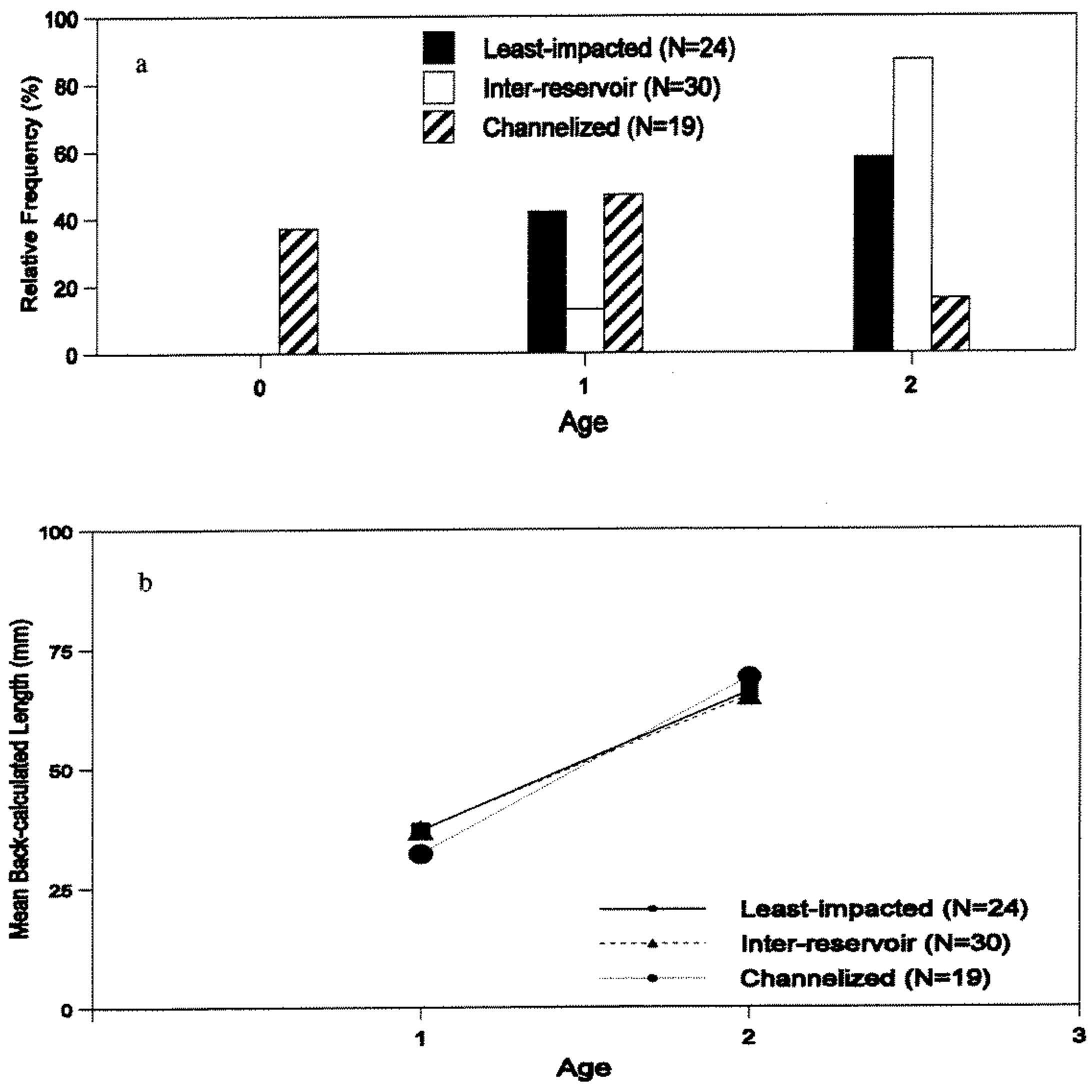


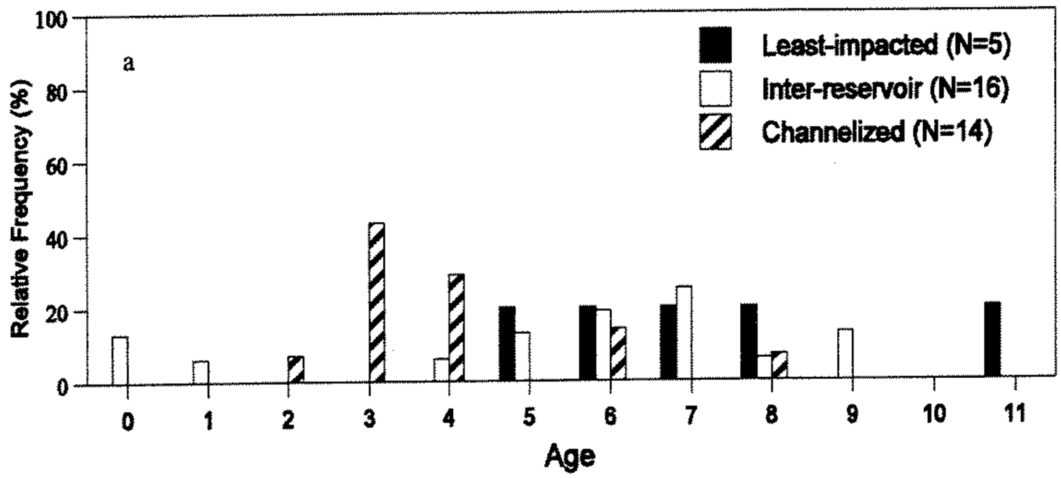
Figure 100. Age frequency distribution (b) and mean back-calculated length at age (b) for sicklefin chubs collected in 1996.

Smallmouth Buffalo

Thirty-five smallmouth buffalo were used for age and growth purposes with maximum ages varying from 8 to 11 years among the three zones. The small sample size may have considerable influence on relative age frequencies. The least-impacted zone appears to consist mainly of older fish while the populations in the lower zones contain younger individuals (Figure 101). This trend is fairly consistent with the other species analyzed. Through age-2, growth is similar among zones (Table 43). However, as also seen for shovelnose sturgeon, the least-impacted and inter-reservoir zone estimates of length at age are less than the channelized zone in the following years of life.

Table 43. Analysis of variance comparisons of mean back-calculated lengths for the 1990 year-class of smallmouth buffalo among three Missouri River zones. Similar letters indicate no difference among means for each age (differences declared at the $P \leq 0.05$ level). Standard errors for each mean length estimate are listed in parentheses.

	Mean Back-calculated Length (mm)		
Age	Least-Impacted (N = 1)	Inter-Reservoir (N = 3)	Channelized (N = 2)
1	120[a]	119[a] (4.0)	146[a] (14.1)
2	180	185 (6.9)	207 (16.5)
3	216	248 (8.2)	280 (16.8)
4	258	308 (10.0)	348 (16.3)
5	283	363 (14.0)	400 (15.6)
6	313[a]	402[b] (16.1)	459[c] (13.8)



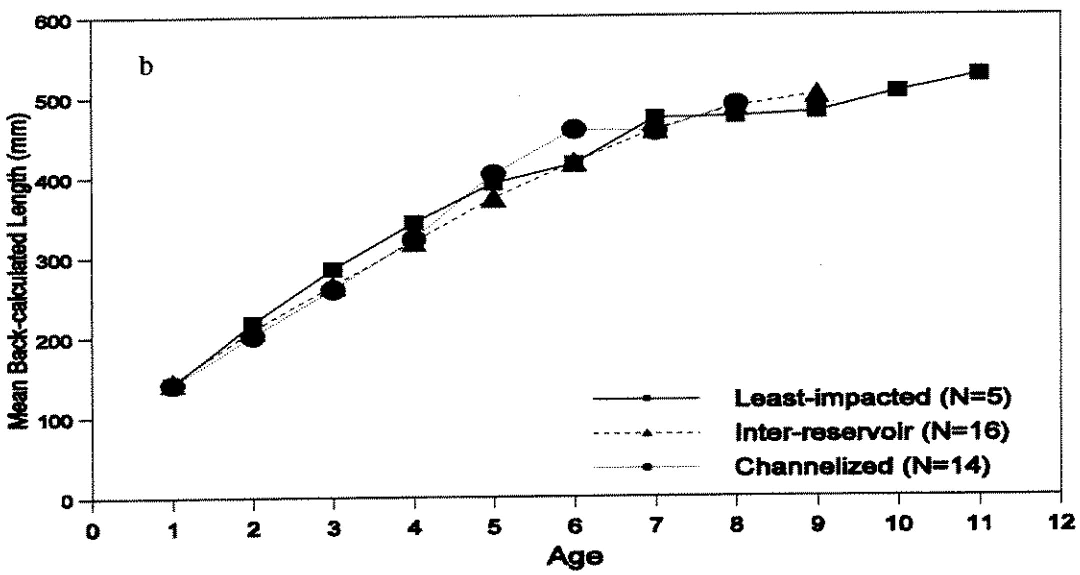


Figure 101. Age frequency distribtution (a) and mean back-calculated length at age (b) for smallmouth buffalo collected in 1996.

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Appendices

Appendix A.. Acronyms for Missouri River Benthic Fish Consortium cooperating agencies, macro- and mesohabitats, fish collection gears, and fishes (including scientific names) used in this report.

AGENCIES

BOR	Bureau of Reclamation
COE	Corps of Engineers
ECRC	Environmental and Contaminants Research Center
IACRU	Iowa Cooperative Fish and Wildlife Research Unit
IDCRU	Idaho Cooperative Fish and Wildlife Research Unit
KSCRU	Kansas Cooperative Fish and Wildlife Research Unit
MOCRU	Missouri Cooperative Fish and Wildlife Research Unit
MRBFC	Missouri River Benthic Fish Consortium
MTCRU	Montana Cooperative Fishery Research Unit
MTFWP	Montana Department of Fish, Wildlife, and Parks
SDCRU	South Dakota Cooperative Fish and Wildlife Research Unit
USGS-BRD	Unites States Geological Survey-Biological Resources Division

MACRO- and MESO-HABITATS

Continuous Macrohabitats:

CHXO	Main Channel Cross-Over
ISB	Inside Bend
ISB-BARS	Inside Bend Bar
ISB-CHNB	Inside Bend Channel Border
ISB-POOL	Inside Bend Pool
ISB-STPS	Inside Bend Steep Shoreline
OSB	Outside Bend

Appendix A. continued

<u>Discrete Macrohabitats:</u>	
SCC	Secondary Channel: Connected
SCC-DEEP	Secondary Channel Connected: Deep
SCC-SHLW	Secondary Channel Connected: Shallow
SCN	Secondary Channel: Non-Connected
TRM	Tributary Mouth
<u>Discrete Macrohabitats</u>	
TRM-LRGE	Large Tributary Mouth
TRM-SMLL	Small Tributary Mouth
WILD	Wild Card Macrohabitat

FISH COLLECTION GEARS

BS	Bag Seine
BT	Benthic Trawl
DTN	Drifting Trammel Net
EF	Boat Electrofishing
SGN	Stationary Gill Net

COMMON AND SCIENTIFIC NAMES OF FISHES
(arranged alphabetically by four-letter code)

Code	Common Name	Scientific Name
BDKF	Banded killifish	*Fundulus diaphanus*
BHCP	Bighead carp	*Hypopthalmichthys nobilis*
BHMW	Bullhead minnow	*Pimephales vigilax*
BKBH	Black bullhead	*Ameiurus melas*
BKCP	Black crappie	*Pomoxis nigromaculatus*
BKSB	Brook stickleback	*Culaea inconstans*
BKSS	Brook silverside	*Labidesthes sicculus*
BLCF	Blue catfish	*Ictalurus furcatus*
BLGL	Bluegill	*Lepomis macrochirus*
BMBF	Bigmouth buffalo	*Ictiobus cyprinellus*
BMSN	Bigmouth shiner	*Notropis dorsalis*

Appendix A. continued

Code	Common Name	Scientific Name
BNMW	Bluntnose minnow	*Pimephales notatus*
BRBT	Burbot	*Lota lota*
BSMW	Brassy minnow	*Hybognathus hankinsoni*
BUSK	Blue sucker	*Cycleptus elongatus*
CARP	Common carp	*Cyprinus carpio*
CKCB	Creek chub	*Semotilus atromaculatus*
CNCF	Channel catfish	*Ictalurus puntatus*
CSCO	Ciscoe	*Coregonus artedi*
ERSN	Emerald shiner	*Notropis atherinoides*
FHCB	Flathead chub	*Platygobio gracilis*
FHCF	Flathead catfish	*Pylodictus olivaris*
FHMW	Fathead minnow	*Pimephales promelas*
FWDM	Freshwater drum	*Aplodinotus grunniens*
GDSN	Golden shiner	*Notemigonus crysoleucas*
GDEY	Goldeye	*Hiodon alosoides*
GNSF	Green sunfish	*Lepomis cyanellus*
GSCP	Grass Carp	*Ctenopharyngodon idella*
GSOS	Green sunfish x Orangespotted	*Lepomis cynellus x L. humilis*
GTSN	Ghost shiner	*Notropis buchanani*
GZSD	Gizzard shad	*Dorosoma cepedianum*
HBNS	Hybognathus sp.	*Hybognathus* sp.
HFCS	Highfin carpsucker	*Carpiodes velifer*
JYDR	Johnny darter	*Etheostoma nigrum*
LESF	Longear sunfish	*Lepomis megalotis*
LKCB	Lake chub	*Couesius plumbeus*
LMBS	Largemouth bass	*Micropterus salmoides*
LNDC	Longnose dace	*Rhinichthys cataractae*

Appendix A. continued

Code	Common Name	Scientific Name
LNGR	Longnose gar	*Lepisosteus osseus*
LNSK	Longnose sucker	*Catostomus catostomus*
LVFS	Larval fish	*Unidentified*
MDSP	Mottled sculpin	*Cottus bairdi*
MQTF	Mosquitofish	*Gambusia affinis*
NHSK	Northern hog sucker	*Hypentelium nigricans*
NRBD	Northern redbelly dace	*Phoxinus eos*
NTPK	Northern pike	*Esox lucius*
OSSF	Orangespotted sunfish	*Lepomis humilis*
PDFH	Paddlefish	*Polydon spathula*
PDSG	Pallid sturgeon	*Scaphirhynchus albus*
PLDC	Pearl dace	*Margariscus margarita*
PNMW	Plains minnow	*Hybognathus placitus*
QLBK	Quillback	*Carpiodes cyprinus*
RBST	Rainbow smelt	*Osmerus mordax*
RBTT	Rainbow trout	*Oncorhynchus mykiss*
RDSN	Red shiner	*Cyprinella lutrensis*
RKBS	Rock bass	*Ambloplites rupestris*
RVCS	River carpsucker	*Carpoides carpio*
RVRH	River redhorse	*Moxostoma carinatum*
RVSN	River shiner	*Notropis blennius*
SCBS	Striped bass	*Morone saxatilis*
SFCB	Sicklefin chub	*Macrhybopsis meeki*
SFSN	Spotfin shiner	*Cyprinella spiloptera*
SGCB	Sturgeon chub	*Macrhybopsis gelida*
SGER	Sauger	*Stizostedion canadense*
SGWE	Sauger x Walleye	*Stizostedion canadense x S. vitreum*

Appendix A. continued

Code	Common Name	Scientific Name
SHRH	Shorthead redhorse	*Moxostoma macrolepidotum*
SKCB	Speckled chub	*Macrhybopsis aestivalis*
SMBF	Smallmouth buffalo	*Ictiobus bubalus*
SMBS	Smallmouth bass	*Micropterus dolomieu*
SMMW	suckermouth minnow	*Phenacobius mirabilis*
SNGR	Shortnose gar	*Lepisosteus platostomus*
SNSN	Shovelnose sturgeon	*Scaphirhynchus platorynchus*
SNSN	Sand shiner	*Notropis stranimeus*
STBS	Spotted bass	*Micropterus punctulatus*
STCT	Stonecat	*Noturus flavus*
STGR	Spotted gar	*Lepisosteus oculatus*
STSN	Spottail shiner	*Notropis hudsonius*
SVCB	Silver chub	*Macrhybopsis storeriana*
TFSD	Threadfin shad	*Dorosoma petenense*
UNID	Unidentified	*Unidentified*
U-BF	Unidentified buffalo	*Ictiobus* sp.
U-CY	Unidentified minnow	*Unidentified Cyprinidae*
U-CN	Unidentified sunfish	*Unidentified Centrarchidae*
U-CS	Unidentified carpsucker	*Carpiodes* sp.
U-CT	Unidentified sucker	*Unidentified Catostomidae*
U-LP	Unidentified *Lepomis*	*Lepomis* sp.
U-NO	Unidentified shiner	*Notropis* sp.
U-RH	Unidentified redhorse	*Moxostoma* sp.
U-ST	Unidentified *Stizostedion*	*Stizostedion* sp.
WLYE	Walleye	*Stizostedion vitreum*
WSMW	Western silvery minnow	*Hybognathus argyritis*
WTBS	White bass	*Morone chrysops*
WTCP	White crappie	*Pomoxis annularis*
WTPH	White perch	*Morone americana*
WTSK	White sucker	*Catostomus commersoni*

Appendix A. continued

Code	Common Name	Scientific Name
YOYF	Age-0 fish (young-of-the-year)	*Unidentified*
YWPH	Yellow perch	*Perca flavescens*

Appendix B.

Riverine Habitat Categories