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

1996 Annual Report
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Executive Summary

The benthic (or bottom-dwelling) fish study is a multi-year, basin-wide research effort to help resource managers evaluate how potential changes in system operating procedures may affect Missouri River fishes. Benthic 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). Many important recreational and commercial fishes are also bottom-dwelling species (e.g., catfishes, sauger, buffaloes). Information on the status of benthic fish populations and their habitat along the entire Missouri River 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.

Research objectives are to: (1) describe and evaluate recruitment, growth, size structure, body condition, and relative abundance of selected benthic fishes, (2) measure physicochemical features (e.g., velocity, turbidity) in dominant habitats where fishes are collected, and (3) describe the use of dominant habitats by benthic fishes. Research is being conducted by six Cooperative Research Units (Montana, Idaho, South Dakota, Iowa, Kansas, Missouri) in the Biological Resources Division (BRD) of the U.S. Geological Survey. Joining in the field work is the Montana Fish, Wildlife & Parks Department (MTFWP) and in data management, data analysis, and qualily assurance/quality control is the BRD Midwest Science Center (MSC), Columbia, MO. Funding through 1996 was received from the U.S. Army Corps of Engineers and the U.S. Bureau of Reclamation.

A hierarchical classification system is used to stratify habitats. The entire river has been divided into nine geo-political sections. Each section is divided into segments (27 total) based on geomorphic and constructed features (e.g., major tributaries, dams). Six macrohabitats have been identified within segments, and include: main channel cross-over, outside bend, inside bend, tributary mouth, connected secondary channel, and non-connected secondary channel (i.e., backwater). These six macrohabitats are present in all river segments and sections and include natural (e.g., sand island, tributary confluence) and man-made (e.g., dike field, revetment) classes.

Physicochemical parameters are collected in conjunction with fish sampling and will help identify fish habitat use within macrohabitats and among study segments and sections. Fish sampling and measurement of physical habitat are conducted in late summer and early fall (e.g., mid-July - October) based on ecologically meaningful bounds (e.g., water temperature). This season was selected because the majority of young-of-year fishes have recruited to our gears; flows are generally low, so all macrohabitats are likely present; and a short duration sampling schedule should reduce within season temporal variability of fish and macrohabitat measurements.

Specific objectives of the 1996 study were to: 1) finalize study segments, 2) develop and test Standard Operating Procedures for data collection and analysis, 3) test alternative fish sampling gears, 4) conduct a formal field season, and 5) communicate project design and preliminary results to interested agencies.

Eighteen of the 27 segments were sampled in 1996 due to financial and logistic considerations. Nineteen Standard Operating Procedures were developed and tested in 1996 that encompass fish collections, fish identifications and body measurements, physicochemical measurements, data analyses, and quality assurance/quality control measures. Fish collection gears include set gill nets, drifting trammel nets, boat electrofishing, seining, and trawling. Collected fish are identified and enumerated, but length and weight are measured only on 26 taxa (benthic guild). Physicochemical variables are depth, velocity, substrate type, bed form, air and water temperature, turbidity, conductivity, geographical location, river stage, and weather.

Twelve alternative fish collection gears and procedures were evaluated prior to the formal field season in most study sections. Alternative fish collection gears, and states where they were tested ( ) include a trammel seine (IA, KS), hoop nets (IA, MO), and fyke nets (MT, IA). Alternative fish collection procedures, where accepted fish collection gears are used in non-standardized macrohabitats, included gill nets set in secondary connected channels and overnight in other macrohabitats, electrofishing non-connected secondary channels and varying electrofishing settings (e.g., amps and volts), and trammel netting and benthic trawling wing dam pools. Most catch rates were low or procedures hard to duplicate in other study sections, so few changes were incorporated.

The first formal field season began on July 8 and was completed in 16 weeks. Physicochemical measurements at fish collection sites were compared among segments and macrohabitats. In general, physicochemical comparisons exhibited significant interactions and segment differences, while macrohabitat comparisons varied. Segment by macrohabitat interactions showed channel cross-overs and outside bends generally increased in depth, velocity, turbidity, and water temperature from upstream to downstream. Inside bends generally increased in depth, water temperature, and turbidity, but had similar velocities from upstream to downstream. Tributary mouths and non-connected secondary channels (i.e., backwaters) were similar across segments in terms of depth, velocity, and turbidity, but water temperatures increased from upstream to downstream. Connected secondary channels (i.e., chutes and braided channels) also had similar depths and velocities among segments, but increased in water temperature and turbidity from upstream to downstream. Substrate comparisons revealed differences among segments and macrohabitats. Percent of bottom substrates composed of sand increased from upstream to downstream segments in connected secondary channels, but decreased in outside bend macrohabitats. Other macrohabitats had similar percentages of sand in their substrates along the river. Gravel percentages generally decreased, while silt percentages increased from upstream to downstream.

A total of 25,692 fishes representing at least 78 taxa and two hybrids were collected. These included nine introduced species and all target taxa except pallid sturgeon. The most species (40) were collected in the segment downstream of Gavins Point Dam, SD/NE (i.e., segment 15) and the least (16) in segments below Fort Peck Dam, MT (i.e., segments 6 and 7). In upper river sections, dominant taxa included flathead chub and *Hybognathus* species. In downstream sections, flathead chub were replaced by gizzard shad and channel and flathead catfish. Relative abundance Tables and habitat use, size structure, and relative abundance Figures for all target taxa collected in 1996 are presented by sections and segments.

Statistical comparisons of relative abundance data were not complete as of this report, but general distribution patterns were evident. Fifteen taxa: shovelnose sturgeon, common carp, sturgeon chub, sicklefin chub, emerald shiner, sand shiner, *Hybognathus* spp., blue sucker, bigmouth buffalo, smallmouth buffalo, river carpsucker, channel catfish, walleye, sauger, and freshwater drum were collected throughout the Missouri and Lower Yellowstone Rivers; 6 species: flathead chub, fathead minnow, white sucker, shorthead redhorse, stonecat, and burbot were primarily collected in least-impacted and inter-reservoir segments, and; 2 species: blue catfish and flathead catfish were only collected in channelized segments.

Habitat use information, expressed as the percentage of all individuals of each taxa collected in various intervals of physicochemical variables (e.g., 0-1 m, 1-2 m, 2-3 m depths) are presented for all target taxa collected. In general, depth and velocity patterns for most taxa were skewed to shallow depths (generally < 2 m) and slower velocities (generally < 0.6 m/s). Taxa with high percentages (> 75%) in these areas were common carp, flathead chub, sand shiner, *Hybognathus* spp., fathead minnow, bigmouth buffalo, smallmouth buffalo, river carpsucker, shorthead redhorse, white sucker, burbot, walleye, sauger, and freshwater drum. Species that had high percentages in deeper water (2-6 m) and faster velocity (0.6-1.2 m/s) areas included shovelnose sturgeon, sturgeon chub, sicklefin chub, blue sucker, blue catfish, and stonecat. Turbidity and water temperature patterns were more variable. No species had their highest percentages in the most turbid (> 500 NTUs), warm waters (> 28 °C). Only blue catfish and freshwater drum had their highest percentages in moderately turbid waters (100-500 NTUs). Remaining taxa were generally collected in waters with turbidities < 100 NTUs. All taxa except white sucker had their highest percentages in moderately warm waters (18-20 °C). White suckers were generally collected in cool water temperatures (<18 °C).

Our total size structure sample after only one year of collection is too small to permit final analyses at this time. However, observations which will be examined more carefully for possible trends in subsequent years include more small individuals (generally < 50 mm and likely juveniles) of channel catfish, freshwater drum, and shovelnose sturgeon in downstream segments. Also, many more larval and unidentifiable age-0 fishes were collected in upstream segments. This may indicate that some species are spawning later in upper segments and may not be recruited to our gears at the time of sampling in Montana and North Dakota. Conversely, these species may spawn earlier in Kansas and Missouri and grow to a larger, more gear susceptible size, thus aiding capture and identification. Standard Operating Procedures for fish collection were modified slightly after the 1996 field season to increase fish catches and clarify methods.

Age and growth information is being collected for 13 taxa. Iowa, Kansas, and Idaho Units began preparing hard part body structures for age and growth analysis when field work was completed in September. Two hard body parts per fish for most taxa are used for aging purposes whenever possible to validate aging methods, which has increased processing time. Results from age and growth estimates will be presented at a June 1997 workshop and included in the 1997 Annual Report. Structures were received from about 235 shovelnose sturgeon, 30 smallmouth buffalo, 490 channel catfish, 80 flathead chub, 829 *Hybognathus* spp., 28 blue sucker, 470 river carpsucker, 355 freshwater drum, 103 sauger, 83 sicklefin chub, 1,277 emerald shiner, and 100 sand shiner.

The Missouri River Benthic Fish Consortium presented an overview of the project at ten meetings in 1996. Oral formats were used at nine meetings, while a poster format was used at the 58th Annual Midwest Fish and Wildlife Conference in Omaha, NE, in December. This poster included preliminary data from the first field season. Oral presentations were generally given to state and federal agencies at various annual meetings (e.g., Missouri Department of Conservation's Big Rivers/Catfish winter meeting; Mid-year meeting, Rivers and Streams Technical Committee, North Central Division, American Fisheries Society). Consortium personnel also participated in three Consortium workshops. These workshops encompassed statistical design, standard operating procedures development, oral progress reports of preliminary gear sampling, standard operating procedures testing, discussions of temporal sampling schedules, and preliminary observations from the first field season.

This annual report is partially a synthesis of findings and recommendations made in individual final reports required by Research Work Orders at each Cooperative Research Unit and contained herein. The two proposed additional field seasons (i.e., 1997, 1998) are required to more thoroughly evaluate results of the 1996 field season and test patterns observed thus far.

Table of Contents

List of Tables

Table Page

Table	Page

Table | Page

Table	Page

Table	Page

Table	Page

List of Figures

Figure	Page

Figure | Page

Figure Page

Figure Page

Figure	Page

Figure Page

List of Appendices

Introduction

The overall goal of this study is to provide resource agencies with fundamental biology and habitat use information for important bottom living fishes collected in a comparable manner for the entire Missouri and Lower Yellowstone Rivers. 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 Missouri River "benthic fish study" is designed to evaluate population structure and habitat use of bottom-dwelling fishes along the main-stem Missouri River, exclusive of reservoirs. This group of fishes was selected because it contains eight of the nine species identified as "at risk" (indicated by *) by state and federal agencies (pallid sturgeon*, *Scaphirhynchus albus*; lake sturgeon*, *Acipenser fulvescens*; blue sucker*, *Cycleptus elongatus*; western silvery minnow*, *Hybognathus argyritis*; plains minnow*, *H. placitus*; sturgeon chub*, *Macrhybopsis gelida*; sicklefin chub*, *M. meeki*; flathead chub*, *Platygobio gracilis*, and paddlefish, *Polyodon spathula*), as well as important recreational and commercial species. The project is being performed by a consortium of Cooperative Research Units (CRU) from universities in Montana, Idaho, South Dakota, Iowa, Kansas, and Missouri, the Montana Department of Fish, Wildlife, and Parks, and the Midwest Science Center (Biological Resources Division, U. S. Geological Survey). Hereafter these groups will be collectively referred to as the Missouri River Benthic Fishes Consortium (MRBFC). Project objectives are 1) describe and evaluate recruitment, growth, size structure, body condition, and relative abundance of selected benthic fishes, 2) measure physicochemical features in dominant macrohabitats where fishes are collected, and 3) describe the use of dominant macrohabitats by benthic fishes.

Goals in 1995 and summarized here were to: 1) establish the study design including hierarchical delineation of Missouri River 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). 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 River (Table 1). Study sections and segments include least-impacted, inter-reservoir, and channelized areas, which are highlighted 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 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) (see Figures in Appendix B). Also, some macrohabitats are very complex, thus they were separated 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 were sampled when present within a segment (referred to hereafter as macrohabitat replicates) with a minimum of two fish collection gears during 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 more stable. A suite of physicochemical variables, including bed form, depth (m), velocity (m/s), substrate, turbidity (NTUs), water temperature (°C), conductivity (uS/cm), macrohabitat coordinates, time, weather conditions, and air temperature (°C) were measured at each fish collection site. Twenty-six benthic fishes historically present in five of the six states under study, were targeted for sampling (Table 2). Also, 15 of the 26 species were targeted for age and growth analyses. One change was made to this list in 1996. Black bullhead were dropped and replaced with flathead catfish because flathead catfish are recreationally important in the lower river. Finally, based on preliminary sampling, five gears were selected 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

Table 1. Spatial study design for sampling benthic fishes along the Missouri and Lower Yellowstone Rivers. Study sections and segments are 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 1996. rmi = river miles.

Section (agency) Description	Segment and Description and (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** (188 rmi)	**06*** Fort Peck Dam-Milk River (rmi 1770.0-1760.0) (10 rmi) **07*** Milk River-Hwy 13 bridge (Wolf Point) (rmi 1760.0-1701.0) (59 rmi) **08*** Wolf Point-Yellowstone River (rmi 1701.0-1582.0) (199 rmi)
3 (MTFWP) 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 1535.0-1389.0)
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 (rmi 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, NE-Big Sioux River (rmi 753.0-740.0) (13 rmi)

Table 1. Continued.

Section (agency) Description	Segment and Description and (location by rmi) (total segment length)
7 (IACRU)	*17** Big Sioux River-Little Sioux River (rmi 740.0-669.2) (70.8 rmi)
Channelized I	*18** Little Sioux River-Platte River (rmi 669.2-595.5) (73.7 rmi)
(242 rmi)	*19** Platte River-Nishnabotna River (rmi 595.5-542.0) (53.5 rmi)
	20 Nishnabotna River-Rulo, NE (rmi 542.0-498.0) (44 rmi)
8 (KSCRU)	*21** Rulo, NE - St. Joseph, MO (rmi 498.0-440.0) (58 rmi)
Channelized II	*22** St. Joseph, MO - Kansas City, MO (rmi 440.0-367.5) (72.5 rmi)
(278 rmi)	*23** Kansas City, MO - Grand River, MO (rmi 367.5-250.0) (117.5 rmi)
	24 Grand River, MO - Glasgow, MO (rmi 250.0-220.0) (30 rmi)
9 (MOCRU)	*25** Glasgow, Missouri-Osage River (rmi 220.0-130.4) (89.6 rmi)
Channelized III	*26* Osage River-about 20 mi upstream of St. Charles, Missouri (rmi 130.4-50.0) (80.4 rmi)
(220 rmi)	
	*27** River mile 50.0-Mississippi River Confluence (rmi 50.0-0.0)

Table 2. Missouri River benthic fish guild, their geographic ranges (from Hesse et al. 1989), and functional category. An * indicates species targeted for age and growth analyses.

Species	Geographic range[a]	Functional category[b]
Pallid sturgeon *Scaphirhynchus albus*	MO, KS, IA, SD, ND, MT	TE
Shovelnose sturgeon* *Scaphirhynchus platorynchus*	MO, KS, IA, SD, ND, MT	
Common carp *Cyprinus carpio*	MO, KS, IA, SD, ND, MT	C
Flathead chub* *Platygobio gracilis*	MO, KS, IA, SD, ND, MT	TE & P
Sturgeon chub *Macrhybopsis gelida*	MO, KS, IA, SD, ND, MT	TE & P
Sicklefin chub* *Macrhybopsis meeki*	MO, KS, IA, SD, ND, MT	TE & P
Emerald shiner* *Notropis atherinoides*	MO, KS, IA, SD, ND, MT	P
Sand shiner* *Notropis stramineus*	MO, KS, IA, SD, ND, MT	P
Western silvery minnow* *Hybognathus argyritis*	MO, KS, IA, SD, ND, MT	TE & P
Plains minnow* *Hybognathus placitus*	MO, KS, IA, SD, ND, MT	TE & P
Brassy minnow* *Hybognathus hankinsoni*	MO, KS, IA, SD, ND, MT	P
Fathead minnow *Pimephales promelas*	MO, KS, IA, SD, ND, MT	P
Blue sucker* *Cycleptus elongatus*	MO, KS, IA, SD, ND, MT	TE
Bigmouth buffalo *Ictiobus cyprinellus*	MO, KS, IA, SD, ND,MT	C
Smallmouth buffalo* *Ictiobus bubalus*	MO, KS, IA, SD, ND, MT	C
River carpsucker* *Carpiodes carpio*	MO, KS, IA, SD, ND, MT	C
White sucker *Catostomus commersoni*	MO, KS, IA, SD, ND, MT	P
Shorthead redhorse *Moxostoma macrolepidotum*	MO, KS, IA, SD, ND, MT	
Flathead catfish* *Pylodictus olivarus*	MO, KS, IA, SD,	R
Channel catfish* *Ictalurus punctatus*	MO, KS, IA, SD, ND, MT	R
Blue catfish *Ictalurus furcatus*	MO, KS, IA, SD	R

Table 2. Continued.

Species	Geographic range[a]	Functional category[b]
Stonecat *Noturus flavus*	MO, KS, IA, SD, ND, MT	P
Burbot *Lota lota*	MO, KS, IA, SD, ND, MT	TE
Walleye *Stizostedion vitreum*	MO, KS, IA, SD, ND, MT	R
Sauger* *Stizostedion canadense*	MO, KS, IA, SD, ND, MT	R
Freshwater drum* *Aplodinotus grunniens*	MO, KS, IA, SD, 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)

(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 3). Acronyms for fishes (including scientific names), participating agencies, fish collection gears and macro- and meso-habitats used in this report can be found in Appendix A for quick reference.

Goals for 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.

Accomplishments

Study segments

Study sections and segments are described in detail in individual section reports.

Standard operating procedures (SOPs) development

Nineteen SOPs were developed in 1996 that described fish sampling protocols (e.g., fish identification and body measurements), physicochemical measurements (e.g., turbidity and conductivity), data analyses, and quality assurance and quality control measures (Table 4). Specific protocols are detailed in Sappington et al. (1996). The SOPs were field tested in spring and early summer of 1996 and modified before standardized sampling. Following the first standardized field season, SOPs were slightly modified for the 1997 field season to increase fish catches and clarify methods (see section reports for more detail).

Preliminary gear testing, SOP testing and additional sampling

Preliminary sampling to test gears and SOPs was conducted during May and June in most study sections. Drifting trammel nets and the benthic trawl collected few fishes in

Table 3. Fish collection gears and Missouri River macro- and meso-habitats they were used in during 1996.

Macro- and meso-habitats	Bag seine	Experimental gill net	Boat electrofishing	Benthic trawl	Drifting trammel net
			Collection gears		
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		
large				X	X
Secondary channels:non-connected	X	X			
Secondary channels:connected					
shallow	X				
deep	X			X	X

Table 4. Standard operating procedures developed for data collection and analyses in 1996 and personnel responsible for them. Summarized from Sappington et al. (1996).

Standard operating procedure	Responsible agency (personnel)
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	MSC (Linda Sappington)
Physicochemical Measurements	
Bed form	MOCRU (Doug Dieterman, David Galat)
Depth and velocity	MOCRU (Doug Dieterman, 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	MSC (Mark Wildhaber)
Fish attributes & physicochemical factors	MSC (Mark Wildhaber)
Hypotheses	MSC (Mark Wildhaber)
Statistical analyses	MSC (Mark Wildhaber)
Data Collection and QA/QC Standard Operating Procedures	
Data sheet coding instructions	MSC (Linda Sappington)
Chain of custody	MSC (Linda Sappington)

channelized sections; conversely, seining, stationary gill nets, and electrofishing collected more (Table 5).

Additional sampling was conducted in many study sections. Additional sampling is sampling conducted with non-standardized gears or in non-standardized time periods. Additional sampling included fish surveys on the floodplain (section *9*), in small tributary mouths in summer, autumn, and winter (section *8*), and in oxbow lakes (section 4) (Table 6). Also, fish were collected with hoop nets (sections *9* and *7*), fyke nets (sections **2** and 7), and a trammel seine (sections *7* and *8*). Some investigators reported catch rates while others only reported species caught. Specific results of some of these studies are contained in individual section reports.

Presentations and workshops

Missouri River Benthic Fish Consortium (MRBFC) personnel participated at numerous meetings in 1996, including Consortium workshops. Three workshops were held in 1996, all in Omaha, Nebraska to facilitate attendance by COE representatives, and nearby state conservation agencies. The first workshop was held in April to discuss SOPs, data sheets and statistical hypotheses and analysis. Representatives from South Dakota (SDCRU), Iowa (IACRU), Kansas (KSCRU), Missouri (MOCRU), Midwest Science Center (MSC), and COE attended. Statistical discussions included sample design, hypotheses, and definitions of population characteristics. A summary of the minutes of the meeting was prepared by David Galat (dated April 22, 1996), and circulated to Consortium members.

The second workshop, (June 21-22) was attended by all consortium members. David Galat gave an oral summary of project goals, objectives and the study design. Oral progress reports were given by each Unit and MTFWP on results from preliminary sampling, SOPs, and additional gear testing. Modifications to SOPs, temporal sampling schedules, and additional statistical considerations were discussed. Finally, Ph.D. candidates summarized prospective research topics. David Galat summarized the minutes of the meeting (dated July 8, 1996), and distributed to appropriate parties.

Table 5. Catch-per-unit-effort of all fishes collected during preliminary sampling from five Missouri River macrohabitats (CHXO - channel crossover; OSB - outside bend; ISB - inside bend; TRM - tributary mouth; SCN - secondary channel non-connected) in sections *7* (Iowa) and *9* (Missouri) during May and June 1996. A "-" indicates the gear was not used in that macrohabitat.

Collection gear (catch-per-unit-effort)	CHXO	OSB	ISB	TRM	SCN
		Section *7* (Iowa)			
Beach seine (#/haul)	-	-	25.3	-	-
Drift trammel net (#/drift)	1.3	0.2	0.0	0.0	-
Benthic trawl (#/tow)	0.0	0.2	0.0	0.0	-
Stationary gill net (#/hour)	-	-	1.9	0.6	-
Electrofishing (#/min)	-	0.3	1.0	0.8	-
		Section *9* (Missouri)			
Beach seine (#/haul)	-	-	-	-	15.0
Drift trammel net (#/drift)	0.0	-	0.0	-	-
Benthic trawl (#/tow)	0.0	0.0	0.0	2.5	-
Stationary gill net (#/hour)	-	-	0.3	2.4	3.8
Electrofishing (#/min)	-	0.9	0.5	68.2	-

Table 6. Results from additional sampling efforts conducted along the Missouri River in 1996. Catch rate information is for all fishes collected.

Method	Month(s)	Results
Section 4 (North Dakota)		
Stationary gill net set in oxbow lakes (backwaters)	August	5.0 fish/hr
Electrofishing oxbow lakes (backwaters)	August	collected 8 species
Stationary gill net set in a deep secondary connected channel	August	ineffective, net clogged with debris
Section 7 (Iowa)		
Trammel seine wing dam pool	July/August	3.0 fish/net
Benthic trawl wing dam pool	August	2.0 fish/haul
Trammel net set across tributary mouth	July/August	8.5 fish/hr
Trammel net set overnight in wing dam pool	September	0.4 fish/hr
Drifting trammel nets over inundated sand bars	July/August	2.8 fish/drift
Electrofishing (60 Hz - outside bends)	August	0.5 fish/min
Electrofishing (40 Hz - outside bends)	August	0.1 fish/min
Fyke nets	September	2.0 fish/net
Hoop nets (non-baited and baited with cheese or cottonseed cakes)	May, June September	0.9 fish/net
Section 8 (Kansas)		
Trammel seine small tributary mouths	June, October December	collected 22 species
Section 9 (Missouri)		
Hoop nets (non-baited) in outside and inside bends	April/November	0.9 fish/net
Electrofishing on the floodplain	June	1.2 fish/min collected 11 species
Electrofishing (60 Hz - inside bends)	June	0.3 fish/min
Electrofishing (60 Hz - outside bends)	June	0.0 fish/min
Electrofishing (50 Hz - outside bends)	July	1.2 fish/min
Electrofishing (20 Hz - inside bends)	June	0.05 fish/min

The third workshop (November 21-23, 1996) was attended by all consortium members and representatives of the U.S. Fish and Wildlife Service, COE, Nebraska Game and Parks Department, and United States Geological Survey (USGS). Following introductions and goals, Robb Jacobson (USGS; Rolla, Missouri) presented a progress report on habitat availability studies. Robb began with a discussion of how the USGS broke the river into study segments, and how they chose representative reaches. Robb concluded with preliminary analyses of habitat data from three sites (Missouri, South Dakota, and North Dakota). Oral progress reports were then given by MRBFC members. Most of these data are presented below and in section reports. Pat Braaten (KSCRU) and Mark Pegg (IACRU) discussed preliminary observations of fish sizes that aging structures were collected from. In general, structures came from smaller fish in the lower river (IA, KS, and MO). However, many small fish had not been processed from upper river sections. Chris Guy (KSCRU) discussed Power Analysis and sample size concerns for age and growth data from the 1996 field season. Also, Mark Wildhaber (MSC) presented details of the statistics to be used on the data, some preliminary analyses, and a potential method for combining catch-per-unit-effort data from different gears. Other topics discussed at the meeting included research work order administration, and SOP revisions.

Workshops proved important for communicating results and sharing field experiences among project participants. Statistical analyses and SOP development benefitted from April and June meetings. Demonstrations of field techniques concerning collection of fish and aging structures conducted in June helped standardize methods. Video tapes of field procedures (e.g., MTFWP-trammel netting; and KSCRU-trammel seining) also helped clarify methods. The November workshop proved important to exchange ideas and further refine SOPs, as well as demonstrate potential statistical tests that will be applied to the data.

Consortium members presented an overview of the project at 11 meetings in 1996 (Table 7). Oral formats were used at nine meetings, while a poster format was used at the 58th Annual Midwest Fish and Wildlife Conference in Omaha, NE in December. This poster received "Runner up" honors in the conference's Open Category. All presentations were given to inform and update interested parties on project progress. The KSCRU presented a

Table 7. Oral and poster presentations given by Missouri River Benthic Fish Consortium members in 1996, exclusive of bi-annual consortium workshops. MOCRU-Missouri Coop Unit, IACRU-Iowa Coop Unit, IDCRU-Idaho Coop Unit, MTFWP-Montana Fish, Wildlife, and Parks, MRBFC-Missouri River Benthic Fishes Consortium, KSCRU-Kansas Coop Unit.

Agency/Meeting	Presenter	Format	Location and Month
Missouri Department of Conservation's, Big Rivers/Catfish winter meeting	MOCRU	Oral	Columbia, MO January
Joint meeting of the Iowa/Nebraska Chapters, American Fisheries Society	IACRU	Oral	Council Bluffs, IA. January
Mid-year meeting, Rivers and Streams Technical Committee, North Central Division, American Fisheries Society	IACRU	Oral	Rock Island, IL April
Planning and Evaluation Workshop: Contaminants in the Mississippi River Basin, National Biological Service's, Biomonitoring of Environmental Status and Trends (BEST) Program	MOCRU	Oral	Columbia, MO June
Meeting with North Dakota Game, Fish, and Parks Department	IDCRU	Oral	July
Bureau of Reclamation DSS meeting	MTFWP	Oral	Billings, MT November
Pallid sturgeon workgroup	MTFWP	Oral	Miles City, MT December
58th Midwest Fish and Wildlife Conference	MRBFC	Poster	Omaha, NE December
58th Midwest Fish and Wildlife Conference	KSCRU	Poster	Omaha, NE December
Missouri River Natural Resources Committee	MOCRU	Oral	twice in 1996

separate poster at the 58th Annual Midwest Fish and Wildlife Conference titled, "Stranding of *Pentagenia vittigera* following flow reductions in the Lower Missouri River."

1996 Field sampling and preliminary results

General

Two study designs were drafted in 1995, a full study that sampled all 27 segments and a reduced study that sampled 18 (Braaten and Guy 1995). The reduced design was chosen in 1996 due to financial and logistic constraints. The number of replicate macrohabitats sampled varied due to availability in each section (e.g., high water reduced the number of ISB-BARS to sample) and other considerations (e.g., MTFWP could not electrofish due to the potential of injuring pallid sturgeon, an endangered species) (Table 8). Field sampling was completed within 16 weeks, and was generally within the agreed upon temporal period (Table 9). Most segments experienced higher than average discharges (Figure 1) due to late spring snows and heavy rains causing large reservoir releases. In general, sampling went well but high water probably reduced sampling efficiency.

Physicochemical variables

While physicochemical variables were measured at each fish collection to characterize fish habitat use, they can provide an index to trends in physicochemical conditions among segments and macrohabitats. It must be recognized, however, that our stratified random sampling approach to measuring physicochemical variables may not yield an accurate representation of habitat availability in each segment. This is because we do not sample habitats in proportion to their availability. Companion research being conducted by the USGS, Biological Resources Division, Mid-Continent Ecological Science Center on the Yellowstone River and USGS, Water Resources Division and COE, Missouri River Division on the Missouri River mainstem is designed specifically to evaluate habitat availability within representative segments (D. Latka, personal communication).

Table 8. The number of replicate macro- and meso-habitats sampled in MRBFC study segments in 1996.

Segment	CHXO	OSB	ISB-BARS	ISB-CHNB	ISB-POOL	ISB-STPS	TRM-SMLL	TRM-LRGE	SCN	SCC-DEEP	SCC-SHLW	WILD
3	5	5	5	5	0	0	0	0	0	0	5	0
5	5	5	5	5	0	5	0	0	2	4	1	0
6	1	0	1	0	0	0	2	0	5	0	5	0
7	5	5	3	5	0	0	4	0	2	1	2	0
8	5	5	5	5	0	0	3	0	5	3	2	0
9	5	5	5	4	0	0	0	0	5	1	4	0
10	5	5	3	2	0	0	0	0	4	1	4	0
12	5	4	4	0	0	0	4	0	5	2	3	1
14	5	4	0	5	0	0	4	0	4	4	0	1
15	5	5	3	2	0	0	5	0	4	3	2	0
17	5	5	1	5	5	5	5	1	0	0	0	0
18	5	5	0	5	5	5	5	1	0	1	0	0
19	5	5	0	5	5	5	5	1	0	1	1	0
21	5	5	1	5	5	5	5	2	0	1	0	0
22	5	5	1	5	5	5	5	2	1	0	1	0
23	5	5	1	5	5	5	5	1	1	5	3	0
25	5	5	5	5	5	5	5	1	1	3	2	0
27	5	5	5	5	5	5	3	0	5	3	2	0

Table 9. Temporal sampling schedule for Missouri River benthic fish and physicochemical data collection in 1996. Bold numbers are transition weeks between months.

Segments	Week of															
	July				August				September					October		
(Agency)	8-14	15-21	22-28	**7/29-8/4**	5-11	12-18	19-25	**8/26-9/1**	2-8	9-15	16-22	23-29	**9/30-10/6**	7-13	14-20	21-28
3, 5 (MTCRU)			X	X	X	X	X	X	X	X	X					
6, 7, 8, 9 (MTFWP)		X	X	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	X								
17, 18, 19 (IACRU)			X	X	X	X	X	X	X							
21, 22, 23 (KSCRU)				X	X	X	X	X	X	X	X	X				
25, 27 (MOCRU)				X	X	X	X	X	X	X	X					

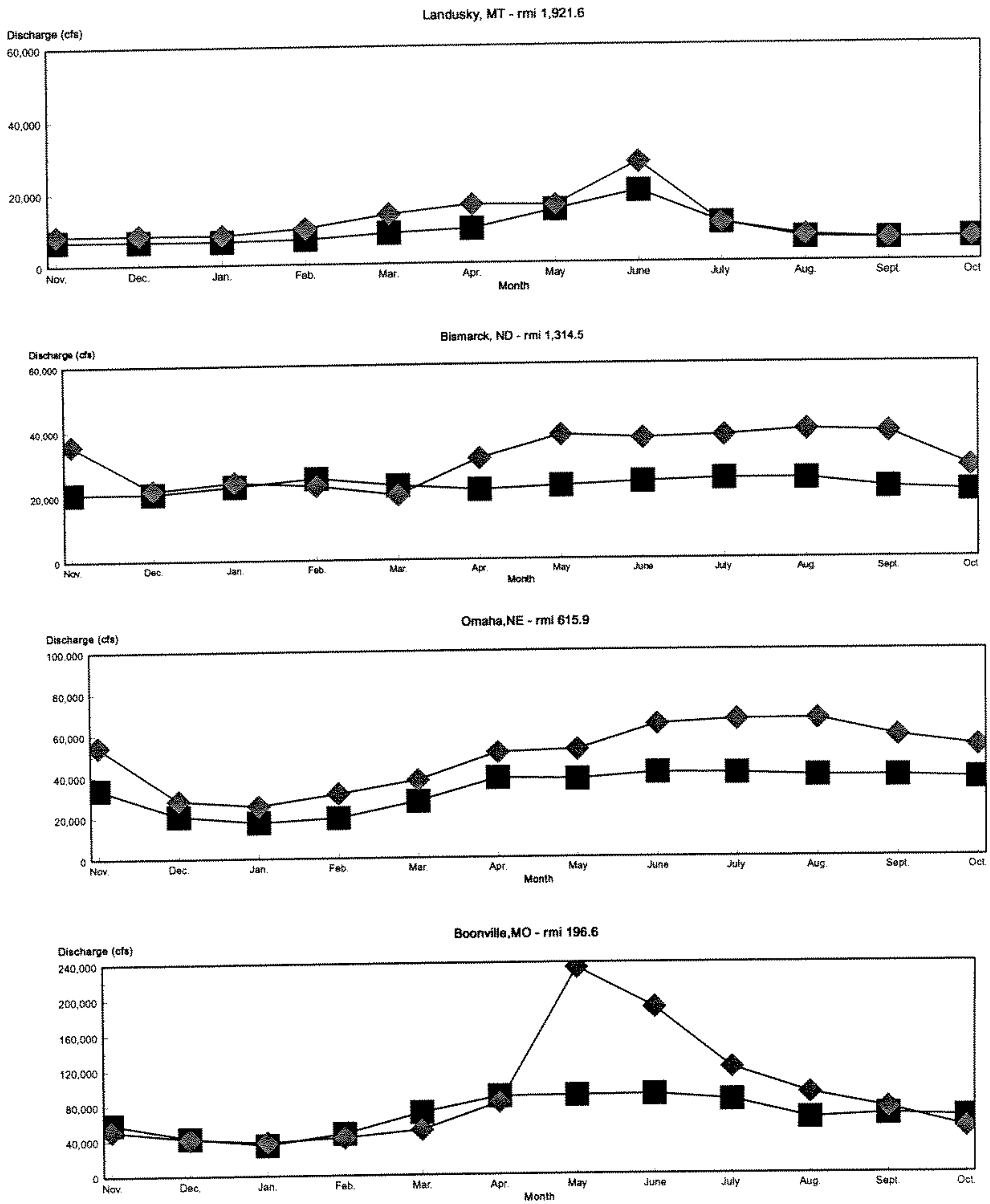


Figure 1. Historic (solid squares: Landusky-1934-1995; Bismark-1954-1995; Omaha and Boonville-1958-1995) and 1996 (solid diamonds) mean monthly discharge for 4 locations along the Missouri River. Note y-axis scales vary with gauging station location.

Physicochemical measurements were compared among segments and macrohabitats by first averaging subsamples (i.e., sites within replicate macrohabitats where an individual gear is deployed and physicochemical measurements taken) by gear within each mesohabitat replicate. These gear values were then averaged producing a value for each mesohabitat replicate. Mesohabitat replicates were then averaged to produce a value for each macrohabitat replicate. For example, ISB-BARS replicate 1 and ISB-CHNB replicate 1 were averaged for ISB **macrohabitat** replicate 1. However, because sampling of ISB-POOLs and ISB-STPSs was not standardized [i.e., few were sampled in non-channelized segments (Table 8)], these physicochemical measurements were not included in macrohabitat replicate averages. Thus, data were collapsed at the lowest common denominator across macrohabitats and segments. The 5 macrohabitat replicates were then averaged within each segment.

Physicochemical variable means were compared among segments and macrohabitats using two-way analysis of variance (ANOVA). Turbidity was $\log_{10}$ transformed and proportion of gravel, sand, and silt were arcsin of the square root transformed to produce normality. Using Miliken and Johnson (1984) as a guide, 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. If segment by macrohabitat interactions were detected, plots of each physicochemical variable by segment were examined for each macrohabitat to discern where interactions occurred. These interaction plots are presented below without standard deviations to help provide; 1) segment trends, and 2) linkages to fish data in subsequent report sections. Fisher's Least Significant Difference test for preplanned comparisons was used to evaluate mean differences. An alpha of 0.05 was selected as evidence of significance in all comparisons.

Average depths across segments and macrohabitats varied from 0.4-6.9 m, average velocities from 0.0-1.8 m/s, average water temperatures from 8.1-28.2 °C, and average turbidities from 3-354 NTUs (Table 10). Analyses of conductivity and bed form are not included at this time as some of these data are currently being analyzed.

Table 10. Summary statistics for depth, velocity, water temperature, and turbidity in six macrohabitats across all Missouri and Lower Yellowstone River study segments in 1996. Turbidity means and SD are log_{10} transformed. Minimum and maximum values are segment averages.

Macrohabitat	Characteristic	N	Mean	SD	Minimum-Maximum
CHXO	Depth (m)	86	4.53	2.17	1.6 - 6.9
	Velocity (m/s)	82	1.15	0.53	0.6 - 1.7
	Water temperature (C)	86	21.86	4.83	10.0 - 27.2
	Turbidity (NTUs)	82	1.59	0.58	3 - 251
OSB	Depth (m)	83	4.16	1.81	1.5 - 6.3
	Velocity (m/s)	83	0.94	0.43	0.6 - 1.4
	Water temperature (C)	83	22.21	4.68	11.1 - 26.9
	Turbidity (NTUs)	81	1.68	0.53	5 - 316
ISB	Depth (m)	85	2.60	1.84	0.4 - 4.5
	Velocity (m/s)	84	0.73	0.49	0.1 - 1.1
	Water temperature (C)	85	22.31	4.52	11.7 - 27.2
	Turbidity (NTUs)	83	1.70	0.56	3 - 316
TRM	Depth (m)	63	1.91	1.01	1.1 - 3.2
	Velocity (m/s)	63	0.07	0.13	0.0 - 0.3
	Water temperature (C)	62	21.87	4.50	8.1 - 26.2
	Turbidity (NTUs)	62	1.69	0.50	8 - 126
SCC	Depth (m)	67	1.38	1.33	0.4 - 2.9
	Velocity (m/s)	66	0.42	0.33	0.2 - 1.0
	Water temperature (C)	63	20.38	5.01	11.9 - 28.2
	Turbidity (NTUs)	63	1.46	0.54	3 - 200
SCN	Depth (m)	44	1.23	0.90	0.6 - 3.1
	Velocity (m/s)	44	0.03	0.08	0.0 - 0.4
	Water temperature (C)	42	20.49	5.37	8.2 - 27.6
	Turbidity (NTUs)	40	1.34	0.53	3 - 80

Depth (m) differed significantly among segments (P = 0.0001), and macrohabitats (P = 0.0001), 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 trends (Figure 2). Macrohabitats were significantly ($P < 0.05$) different from each other except SCC and SCN which were the shallowest. Depth decreased in macrohabitats in the following order; CHXO, OSB, ISB, TRM, SCC, and SCN (Table 10). Channelized, inter-reservoir, and least-impacted segments generally grouped together in segment only comparisons (Figure 3). Depth (m) was greatest in segment *17* ($\bar{x}$ = 4.37) followed in order by *19* ($\bar{x}$=4.36), *18* ($\bar{x}$=4.34), *21* ($\bar{x}$=4.30), *23* ($\bar{x}$=4.03), *22* ($\bar{x}$=3.76), *25* ($\bar{x}$=3.70), **10** ($\bar{x}$=3.23), *27* ($\bar{x}$=2.96), **14** ($\bar{x}$=2.92), **15** ($\bar{x}$=2.52), **12** ($\bar{x}$=2.31), **7** ($\bar{x}$=2.07), **6** ($\bar{x}$=1.93), 5 ($\bar{x}$=1.82), 3 ($\bar{x}$=1.16), **8** ($\bar{x}$ =1.01), and 9 ($\bar{x}$=0.80).

Like depth, velocity (m/s) differed significantly among segments (P = 0.0001), and macrohabitats (P = 0.0001), and had a significant interaction (P = 0.0001). Velocity increased in channelized segments in CHXOs and OSBs, especially in the transition area between inter-reservoir and channelized segments (i.e., between segments **15** and *17/18),* but showed no trends across segments in ISBs, SCC, SCN, and TRMs (Figure 4). Average velocities were slowest in SCN and TRMs, while CHXOs exhibited the greatest average velocity (Table 10). Outside bends, ISBs, and SCC all had intermediate average velocities. Generally, most channelized and inter-reservoir segments were not significantly ($P > 0.05$) different from each other, but each least-impacted segment was unique (Figure 5). Segments *25* (rmi 220-130) and *27* (rmi 50-0) however, were more similar to inter-reservoir and least-impacted segments than to other channelized segments. Velocity decreased across segments in the following order; segment *18* ($\bar{x}$=1.14), *19* ($\bar{x}$=1.08), *21* ($\bar{x}$=1.01), *17* ($\bar{x}$=0.97), *23* ($\bar{x}$=0.90), *22* ($\bar{x}$=0.85), 3 ($\bar{x}$=0.70), *25* ($\bar{x}$=0.69), *27* ($\bar{x}$=0.60), **7** ($\bar{x}$=0.59), **15** ($\bar{x}$=0.55), **14** ($\bar{x}$=0.54), 5 ($\bar{x}$=0.50), **10** ($\bar{x}$=0.46), **12** ($\bar{x}$=0.45), **6** ($\bar{x}$=0.22), 9 ($\bar{x}$=0.15), and **8** ($\bar{x}$=0.12).

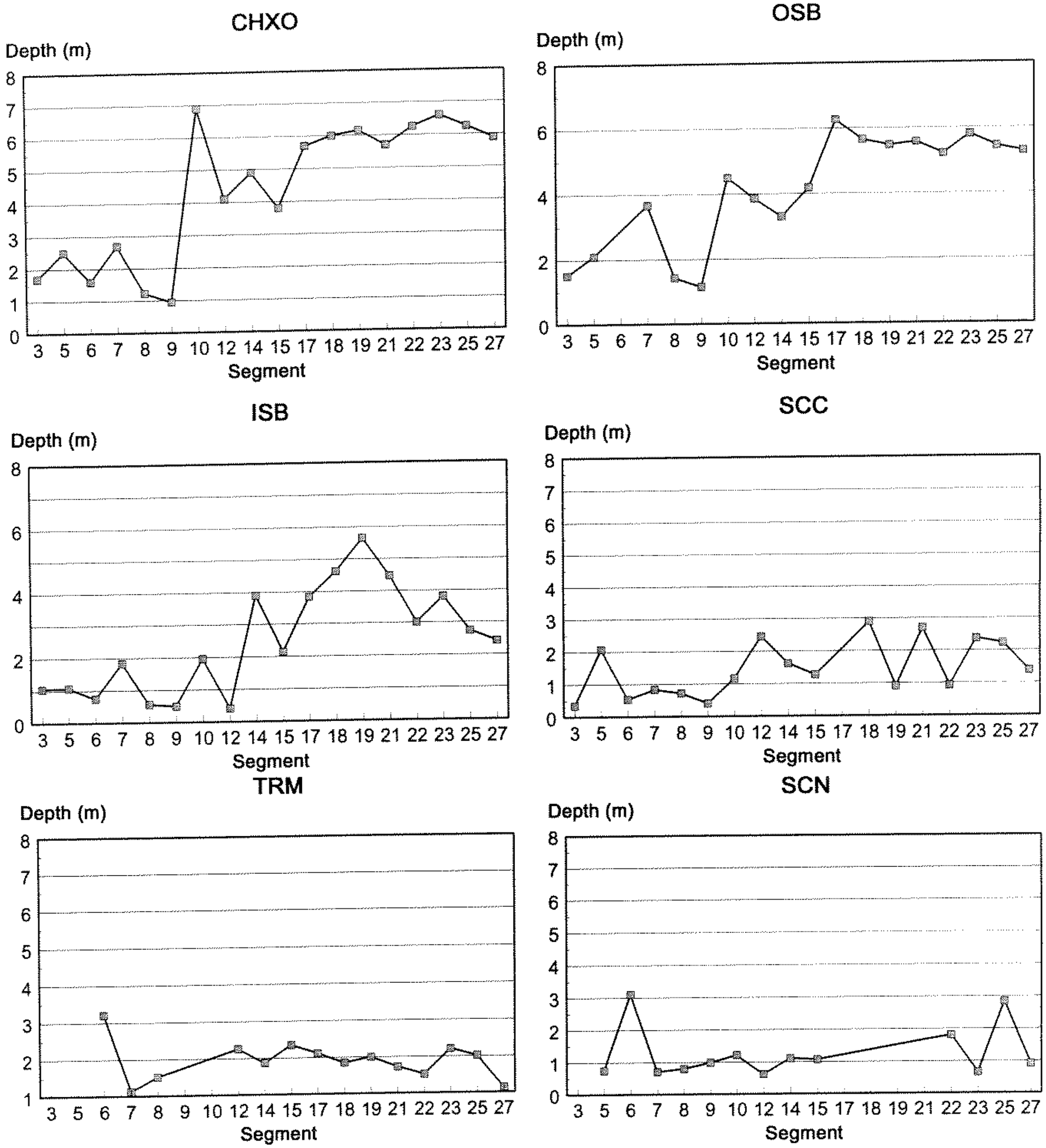


Figure 2. Average depth (m) in Missouri and Yellowstone (segment 9) River study segments measured in 1996 in six macrohabitats. CHXO-main channel crossover; OSB-outside bend, ISB-inside bend, SCC-secondary channel connected; TRM-tributary mouth; SCN-secondary channel non-connected.

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

Figure 3. Depth comparisons matrix for 18 Missouri River study segments where depth was measured in 1996. 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.

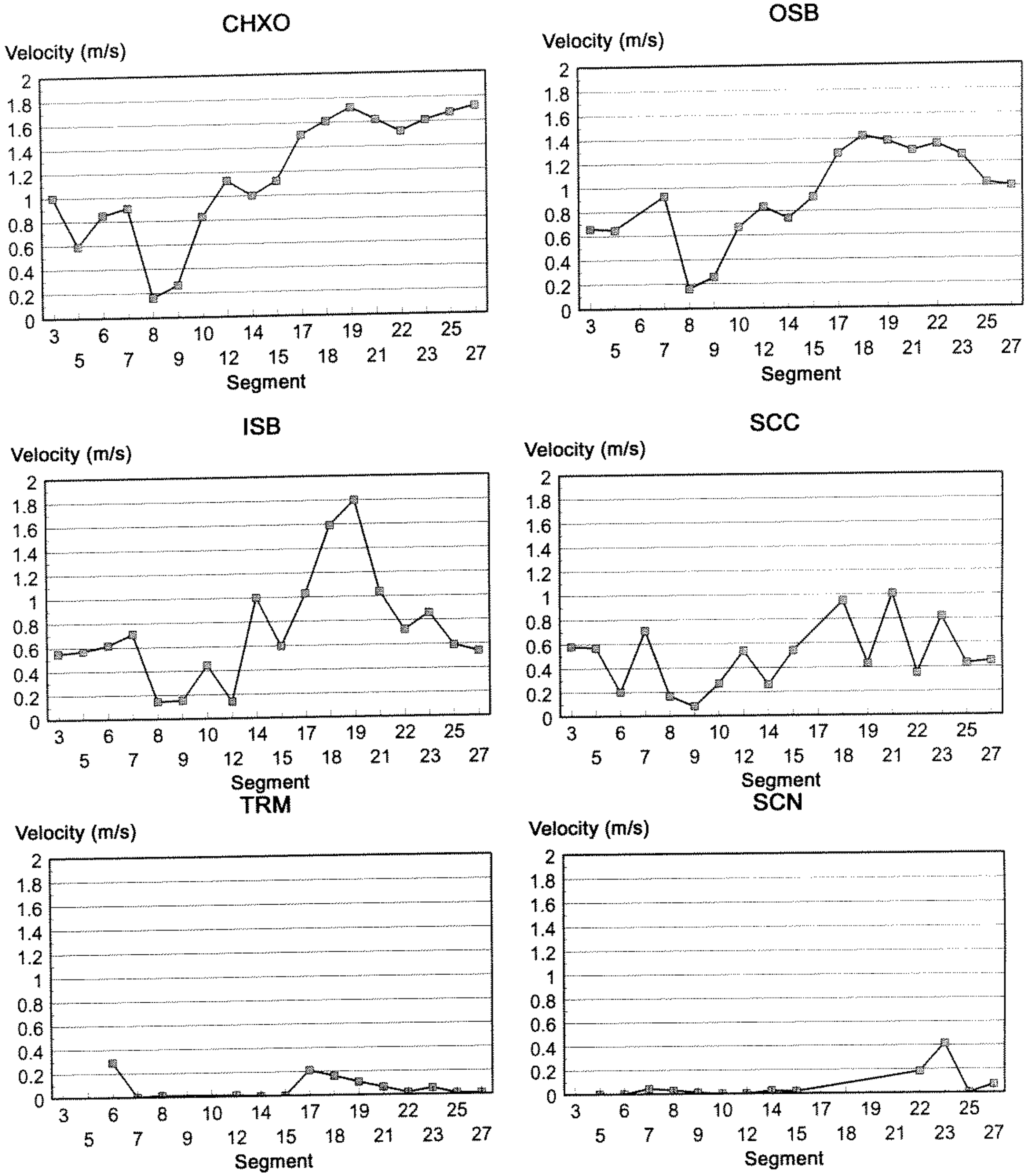


Figure 4. Average water velocity (m/s) in Missouri and Yellowstone (segment 9) River study segments measured in 1996 in six macrohabitats. CHXO-main channel crossover; OSB-outside bend, ISB-inside bend, SCC-secondary channel connected; TRM-tributary mouth; SCN-secondary channel non-connected.

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

Figure 5. Velocity comparisons matrix for 18 Missouri River study segments where velocity was measured in 1996. 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 (°C) differed significantly among segments (P = 0.0001), but not macrohabitats (P = 0.1191). However, there was a significant (P = 0.0013) interaction between segments and macrohabitats. Water temperature by segment plots for each macrohabitat displayed similar trends of increasing temperature in all macrohabitats from Montana to Missouri (Figure 6). Water temperature in segment 3 between rmi 1,999 and 1,980 averaged 21.4 °C, increased to 24.9 °C by rmi 595-542 (segment *19*) and peaked at 27.1 °C near the mouth (rmi 50-0, segment *27*). However, average water temperatures for most macrohabitats declined by at least 6 °C and up to 16 °C in segments below Ft. Peck Dam (segment **6**) and Garrison Dam (segment **12**), but not below lower reservoirs, Ft. Randall Dam (segment **14**) and Gavins Point Dam (segment **15**). Fort Peck (total storage-18,900,000 acre-feet) and Garrison (total storage 24,100,000 acre-feet) dams are the two largest impoundments in this study. The interaction term appeared to be explained by variation in temperatures among macrohabitats in segments **6** and **7**. Few generalized patterns among segments were evident for water temperature (Figure 7). Channelized I and II segments *17* ($\bar{x}$=24.4 °C), *18* ($\bar{x}$=24.8 °C), *19* ($\bar{x}$=24.9 °C), *21* ($\bar{x}$=25.3 °C), *22* ($\bar{x}$=24.4 °C)) and channelized III segment *25* ($\bar{x}$=25.2 °C) had similar water temperatures, as did least-impacted segments (3 ($\bar{x}$=21.4 °C), 5 ($\bar{x}$=22.3 °C), and 9 ($\bar{x}$=22.7 °C)). Inter-reservoir segment comparisons varied extensively, with some differences due to longitudinal position. Segment *27* was significantly (P < 0.05) the warmest ($\bar{x}$ = 27.2 °C) followed by segments *21, 25, 19, 18, 22, 17*, **15** ($\bar{x}$=23.7 °C), *23* ($\bar{x}$= 23.7 °C), **14** ($\bar{x}$=23.7 °C), 9, 5, 3, **10** ($\bar{x}$=19.2 °C), **8** ($\bar{x}$=15.7 °C), **12** ($\bar{x}$=15.6 °C), **6** ($\bar{x}$=14.9 °C), and **7** ($\bar{x}$=10.7 °C).

Like water temperature, turbidity (log transformed NTUs) differed significantly among segments (P = 0.0001), but not macrohabitats (P = 0.1377). The interaction term was significant (P = 0.0001). Turbidity generally increased in CHXOs, OSBs, ISBs, and SCC from upper to lower river segments, especially between rmi 440-367 (segment *22*, $\bar{x}$= 80.2 NTUs) and rmi 220-130 (segment *25*, $\bar{x}$=157.8 NTUs) (Figure 8). Turbidity decreased in segment *27* near the mouth (rmi 50-0, $\bar{x}$=114.8 NTUs). Secondary channels:non-connected and TRMs displayed no turbidity trends across segments. Comparisons among segments exhibited few generalized patterns (Figure 9). Some channelized segments had similar

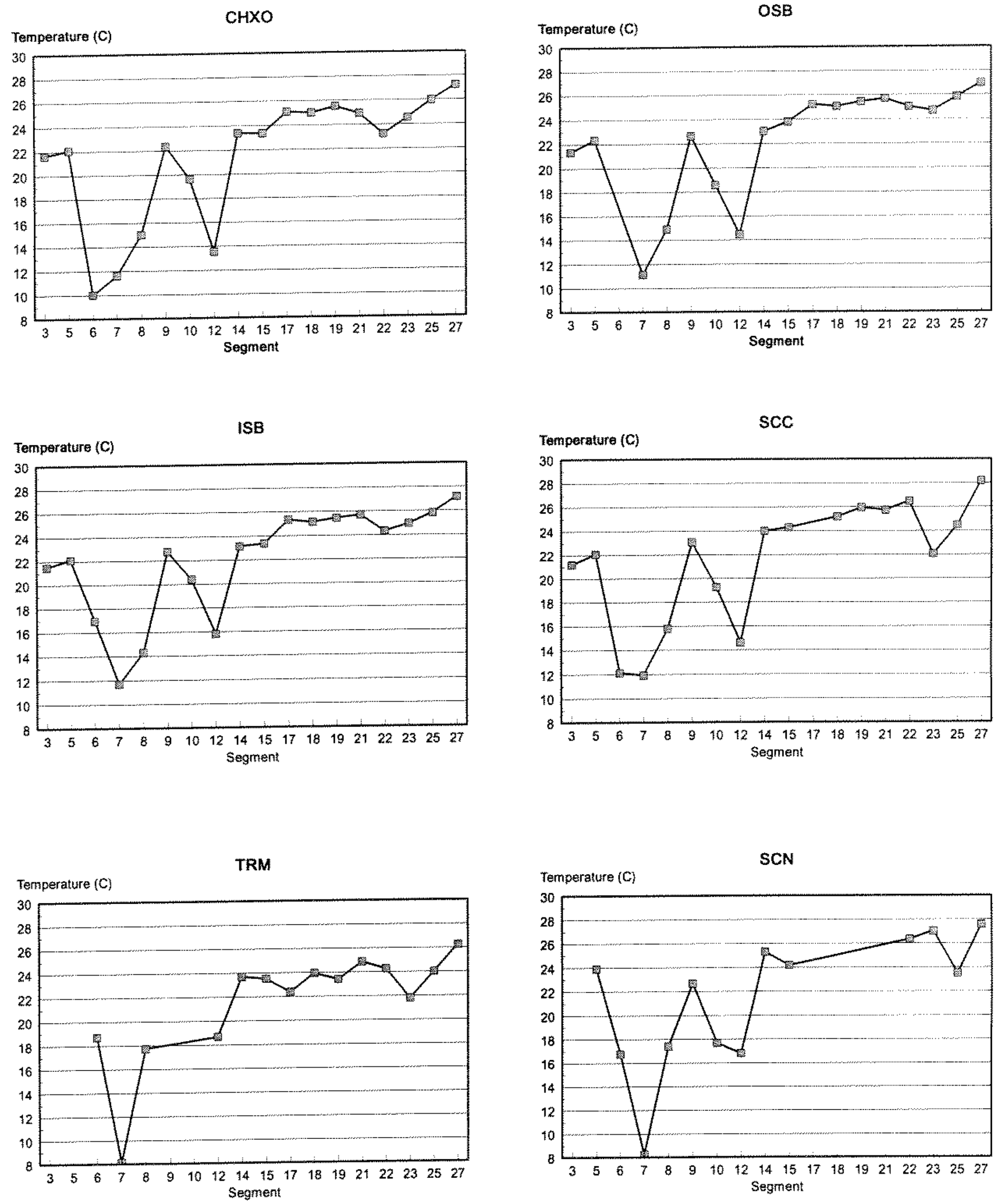


Figure 6. Average water temperatures (°C) in Missouri and Yellowstone (segment 9) River study segments measured in 1996 in six macrohabitats. CHXO-main channel crossover; OSB-outside bend, ISB-inside bend, SCC-secondary channel connected; TRM-tributary mouth; SCN-secondary channel non-connected.

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

Figure 7. Water temperature comparisons matrix for 18 Missouri River study segments where water temperature was measured in 1996. 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.

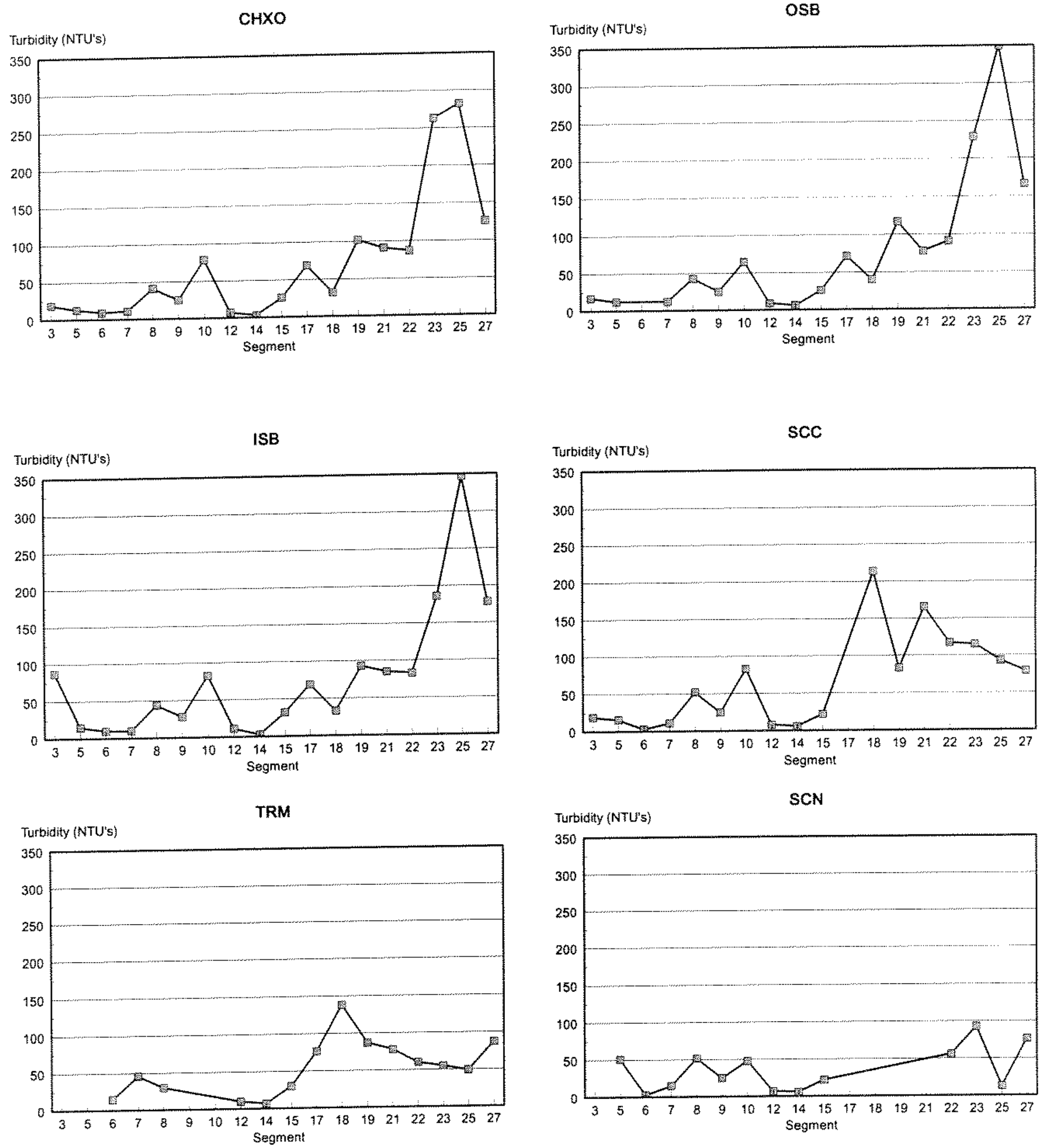


Figure 8. Average turbidity (NTUs) in Missouri and Yellowstone (segment 9) River study segments measured in 1996 in six macrohabitats. CHXO-main channel crossover; OSB-outside bend, ISB-inside bend, SCC-secondary channel connected; TRM-tributary mouth; SCN-secondary channel non-connected.

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

Figure 9. Turbidity comparisons matrix for 18 Missouri River study segments where turbidity was measured in 1996. 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.

turbidities, as did least-impacted segments (3, 5, and 9). Inter-reservoir segments **6** and **14** had the lowest segment average turbidities ($\bar{x}$= 4.4 and 4.6 NTUs, respectively) and were the only inter-reservoir segments that were not different from each other. Turbidity (NTUs) decreased in the following segment order; *25, 23* ($\bar{x}$=145.5), *27, 19* ($\bar{x}$=97.9), *21* ($\bar{x}$=86.5), *22, 17* ($\bar{x}$=72.4), **10** ($\bar{x}$=72.3), *18* ($\bar{x}$=55.1), **8** ($\bar{x}$=44.3), 3 ($\bar{x}$=27.8), **15** ($\bar{x}$=26.9), 9 ($\bar{x}$=25.6), 5 ($\bar{x}$=15.7), **7** ($\bar{x}$=14.4), **12** ($\bar{x}$=8.4), **14**, and **6**. Segments **6**, **12**, **14**, and **15** are immediately downstream from reservoirs (Table 1).

The percent of substrates composed of gravel (arcsine of the square root transformed proportion) was significantly different among macrohabitats (P = 0.0001) and segments (P = 0.0001), however the interaction term was not significantly different (P = 0.6412) (Figure 10). Outside bend substrates had a significantly (P < 0.05) higher percentage of gravel ($\bar{x}$=14%) than other macrohabitats. Channel cross-overs ($\bar{x}$=8%) and SCC ($\bar{x}$= 7%) had lower gravel percentages than OSBs, but were not significantly different (P > 0.05) from each other. Secondary channels:connected and ISBs ($\bar{x}$= 4%) also had lower gravel percentages than OSBs but were not different from each other. Tributary mouths ($\bar{x}$=1%) and SCN ($\bar{x}$= 1%) had little gravel in their substrates with the exception of TRMs in segment **6** ($\bar{x}$=39%). Least-impacted, upriver segments generally had higher gravel percentages in them (e.g., 3 ($\bar{x}$=51%), 5 ($\bar{x}$=16%), and 9 ($\bar{x}$=19%)) than inter-reservoir and channelized, downriver segments (Figure 11). The percent of substrate composed of gravel was greatest in segment 3 followed in descending order, by 9, 5, **6** ($\bar{x}$=14%), **7** ($\bar{x}$=7%), *19* ($\bar{x}$=6%), **15** ($\bar{x}$=5%), *27* ($\bar{x}$=4%), **12** ($\bar{x}$=4%), *23* ($\bar{x}$=4%), *22* ($\bar{x}$=1%), **10** ($\bar{x}$=1%), *21* ($\bar{x}$=1%), **8** ($\bar{x}$=1%), **14** ($\bar{x}$=1%), *18* ($\bar{x}$=1%), *17* ($\bar{x}$=1%), and *25* ($\bar{x}$=1%).

The percentage of substrates composed of sand (arcsine of the square root transformed proportion) was significantly different among segments (P = 0.0001) and macrohabitats (P = 0.0001), and the interaction term was also significant (P = 0.0259). Sand substrate percentages increased in SCCs and decreased in OSBs from upper to lower river segments (Figure 12). Other macrohabitats showed no trends. Percent sand substrates were highest in CHXOs ($\bar{x}$=85%), and ISBs ($\bar{x}$=81%), Sand percentages differed among remaining macrohabitats and decreased from $\bar{x}$=71% in SCC to 58% in OSBs,

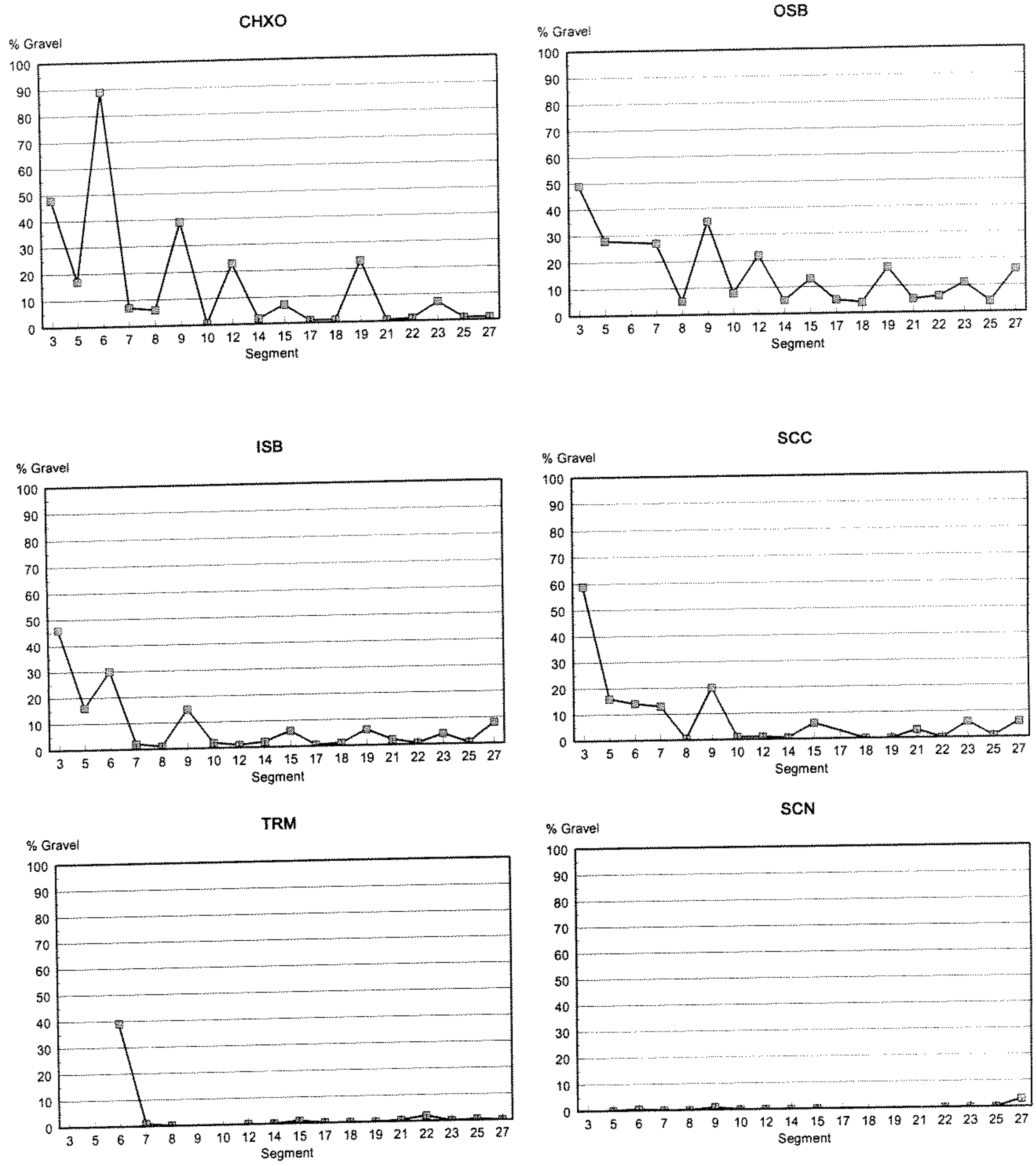


Figure 10. Average gravel substrate percentages in Missouri and Yellowstone (segment 9) River study segments measured in 1996 in six macrohabitats. CHXO-main channel crossover; OSB-outside bend, ISB-inside bend, SCC-secondary channel connected; TRM-tributary mouth; SCN-secondary channel non-connected.

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

Figure 11. Gravel substrate comparisons matrix for 18 Missouri River study segments where substrate was measured in 1996. 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.

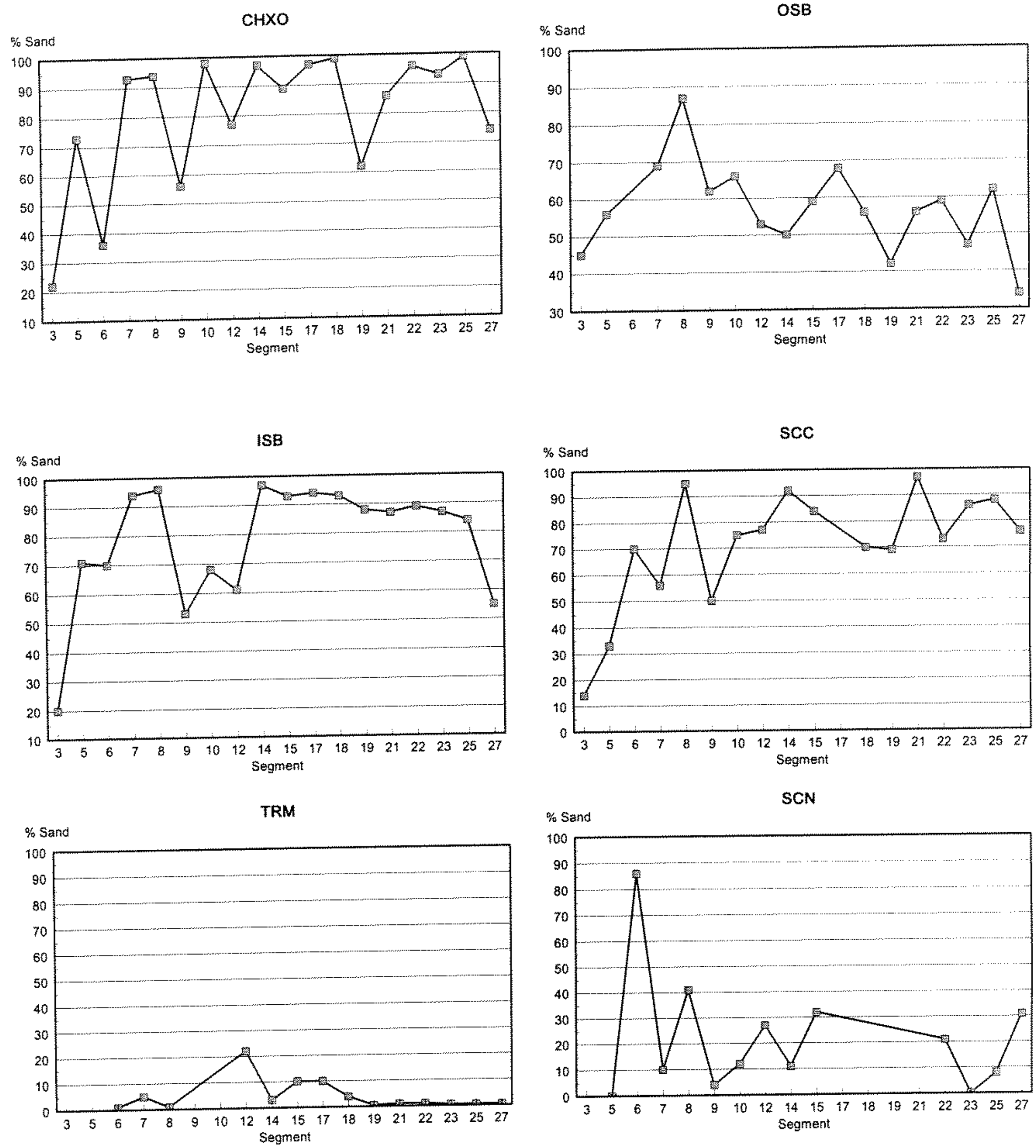


Figure 12. Average sand substrate percentages in Missouri and Yellowstone (segment 9) River study segments measured in 1996 in six macrohabitats. CHXO-main channel crossover; OSB-outside bend, ISB-inside bend, SCC-secondary channel connected; TRM-tributary mouth; SCN-secondary channel non-connected.

24% in SCN and 3% in TRMs. Comparisons among segments revealed few significant ($P < 0.05$) differences, indicating a common substrate at fish collection sites throughout the river (Figure 13). Segments 3, 9, and *19* were generally unique, exhibiting significantly lower sand percentages than most others. Segment **8** had the highest sand substrate percentage ($\bar{x}$=76%) followed by **10** ($\bar{x}$=68%), *17* ($\bar{x}$=68%), **14** ($\bar{x}$=65%), *25* ($\bar{x}$=64%), *18* ($\bar{x}$=64%), **15** ($\bar{x}$=64%), **7** ($\bar{x}$=63%), **6** ($\bar{x}$=62%), *22* ($\bar{x}$=60%), *21* ($\bar{x}$=58%), *23* ($\bar{x}$=58%), **12** ($\bar{x}$=54%), 5 ($\bar{x}$=51%), *27* ($\bar{x}$=46%), *19* ($\bar{x}$=43%), 9 ($\bar{x}$=43%) and 3 ($\bar{x}$=25%).

Substrate percentages composed of silt (arcsin of the square root transformed proportion) were similar to gravel with significant differences among segments ($P = 0.0018$) and macrohabitats ($P = 0.0001$), but no significant interaction ($P = 0.0529$) (Figure 14). As percentages of silt, sand, and gravels must sum to 100%, this probably indicates an inverse relationship between silt and gravel. Silt was the dominant substrate in TRMs ($\bar{x}$=96%) and SCN ($\bar{x}$=73%). ISBs ($\bar{x}$=7%) and SCC ($\bar{x}$=12%) had intermediate percentages and were not significantly ($P > 0.05$) different from each other. Outside bends and CHXOs had the smallest silt percentages ($\bar{x}$=3% and 1%, respectively). Segment comparisons revealed that most segments are not different from each other, again suggesting a common substrate at fish collection sites throughout the river (Figure 15). Segments 3 and **6** had smaller percentages of silt in their substrates than most others ($\bar{x}$=6% and 10%, respectively), while segment *19* had the highest ($\bar{x}$=27%). Segment *19* had the highest silt percentage followed by **12** ($\bar{x}$=27%), **14** ($\bar{x}$=27%), *25* ($\bar{x}$=25%), **10** ($\bar{x}$=23%), *22* ($\bar{x}$=23%), *27* ($\bar{x}$=22%), *23* ($\bar{x}$=21%), 9 ($\bar{x}$=20%), *17* ($\bar{x}$=19%), *21* ($\bar{x}$=17%), **15** ($\bar{x}$=17%), **7** ($\bar{x}$= 17%), 5 ($\bar{x}$=17%), *18* ($\bar{x}$=16%), **8** ($\bar{x}$=16%), **6**, and 3.

In summary, physical habitat and water quality comparisons exhibited significant interactions and segment differences, while macrohabitat comparisons varied. Segment by macrohabitat interactions indicated CHXOs and OSBs generally increased in depth, velocity, turbidity, and water temperature from upstream to downstream. Inside bends generally increased in depth, water temperature, and turbidity, but had similar velocities from upstream to downstream. Tributary mouths and SCN were similar among segments in terms of depth, velocity, and turbidity, but water temperatures increased from upstream to downstream.

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

Figure 13. Sand substrate comparisons matrix for 18 Missouri River study segments where substrate was measured in 1996. 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.

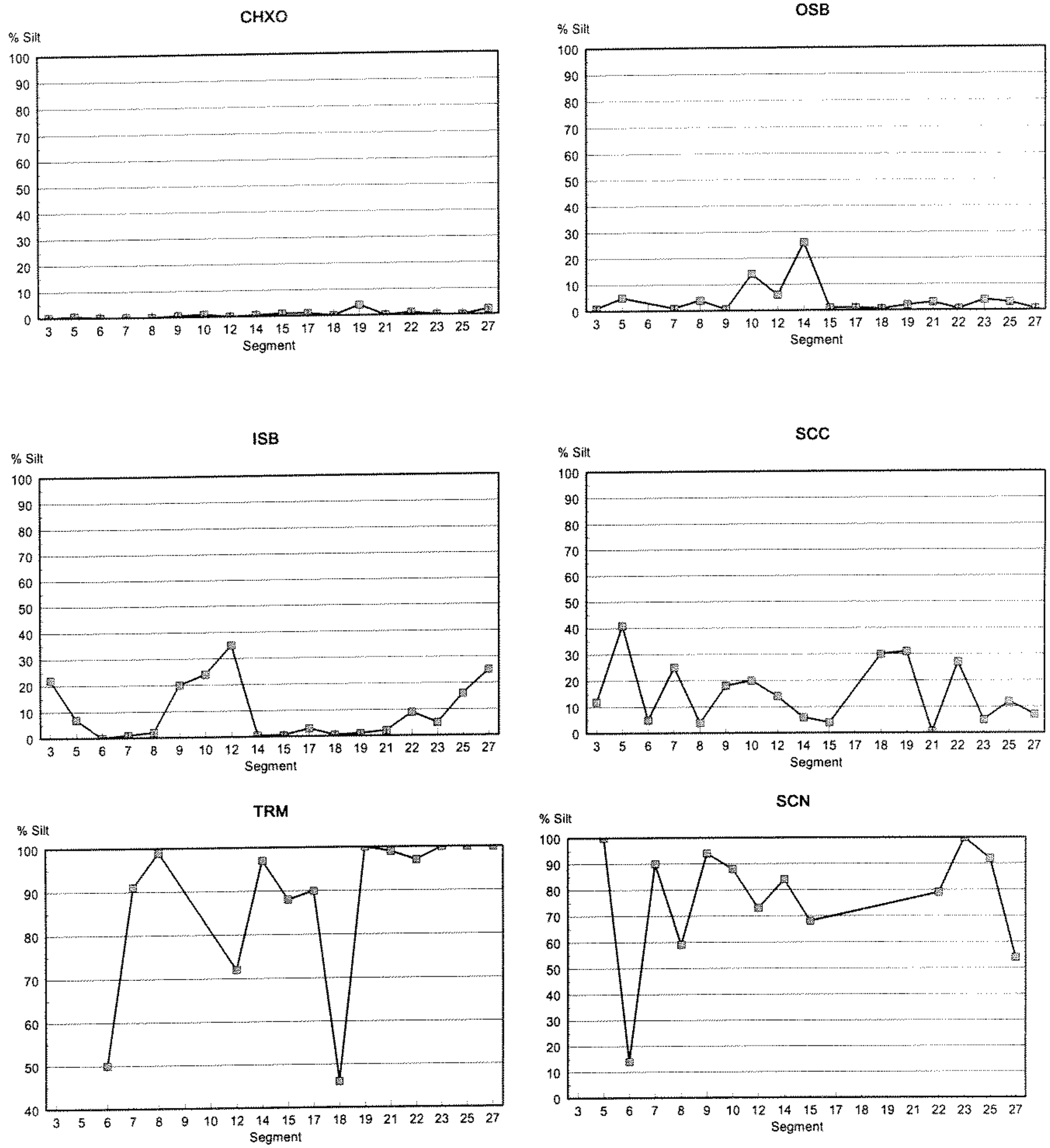


Figure 14. Average silt substrate percentages in Missouri and Yellowstone (segment *9*) River study segments measured in 1996 in six macrohabitats. CHXO-main channel crossover; OSB-outside bend, ISB-inside bend, SCC-secondary channel connected; TRM-tributary mouth; SCN-secondary channel non-connected.

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

Figure 15. Silt substrate comparisons matrix for 18 Missouri River study segments where substrate was measured in 1996. A box with a letter in it means that those segments are not statistically different from each other. <u>N</u> = natural or least-impacted segments, **I** = inter-reservoir segments, and *C* = channelized segments. *C*, **I**, and <u>N</u> 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.

Secondary channels:connected also had similar depths and velocities among segments, but increased in water temperature and turbidity from upstream to downstream. Finally, when segment averaged depth and velocities are plotted together, a general increasing trend from least-impacted to inter-reservoir to channelized segments can be seen (Figure 16). Plots of water quality variables however, reveal a general trend of increasing water temperature and turbidity from inter-reservoir to least-impacted to channelized segments.

Substrate comparisons differed among segments and macrohabitats. Percent of bottom substrates composed of gravel generally decreased, while silt increased from upper to lower river segments (Figure 17). Minimum-maximum segment averages for gravel were 16-51% in least-impacted segments, 1-14% in inter-reservoir segments, and 1-6% in channelized segments. Minimum-maximum segments averages for silt were 6-20% in least-impacted segments, 10-27% in inter-reservoir segments, and 16-27% in channelized segments. Substrates composed of sand generally did not vary among segments. Minimum-maximum segment averages were 25-51% in least-impacted segments, 54-78% in inter-reservoir segments, and 43-68% in channelized segments.

Fishes-general

This study encompasses 1,445 river miles (rmi) on the mainstem Missouri (1,374 rmi) and Lower Yellowstone Rivers (71 rmi), exclusive of reservoirs. During 1996 we collected fishes from replicated macrohabitats along 1,150 rmi, or 80% of the total river, exclusive of reservoirs. A total of 25,692 fishes representing at least 78 taxa (some unidentified) and two hybrids were collected in 1996 (Table 11). These included 9 introduced species and all target fishes except pallid sturgeon. The most species (40) were collected in the unchannelized area below Gavins Point Dam, SD/NE (i.e., segment **15**) and the least (16) in inter-reservoir segments below Fort Peck Dam, MT (i.e., segments **6** and **7**). Fish collection gears appeared to work well because 62% of all identified fishes collected were target benthic taxa. The five numerically dominant taxa varied across study sections (Table 12). In upper river sections, dominant taxa included flathead chub and *Hybognathus* species. In downstream sections, flathead chub were replaced by gizzard shad and channel and flathead catfish.

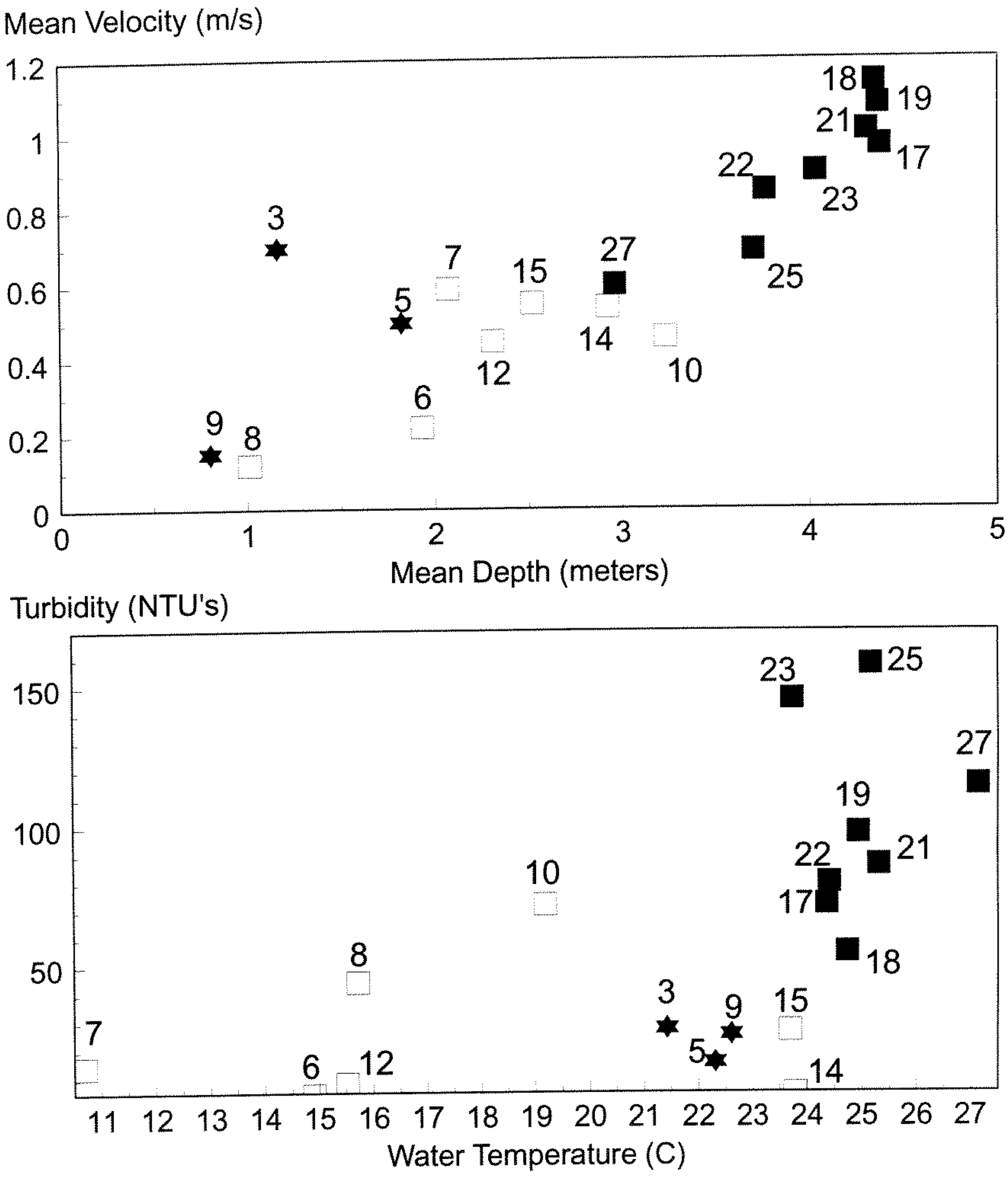


Figure 16. Segment averaged values for physical habitat (depth and velocity) and water quality (temperature and turbidity) variables collected from the Missouri River in 1996. Solid squares = channelized river segments, open squares = inter-reservoir segments, and stars = least-impacted river segments.

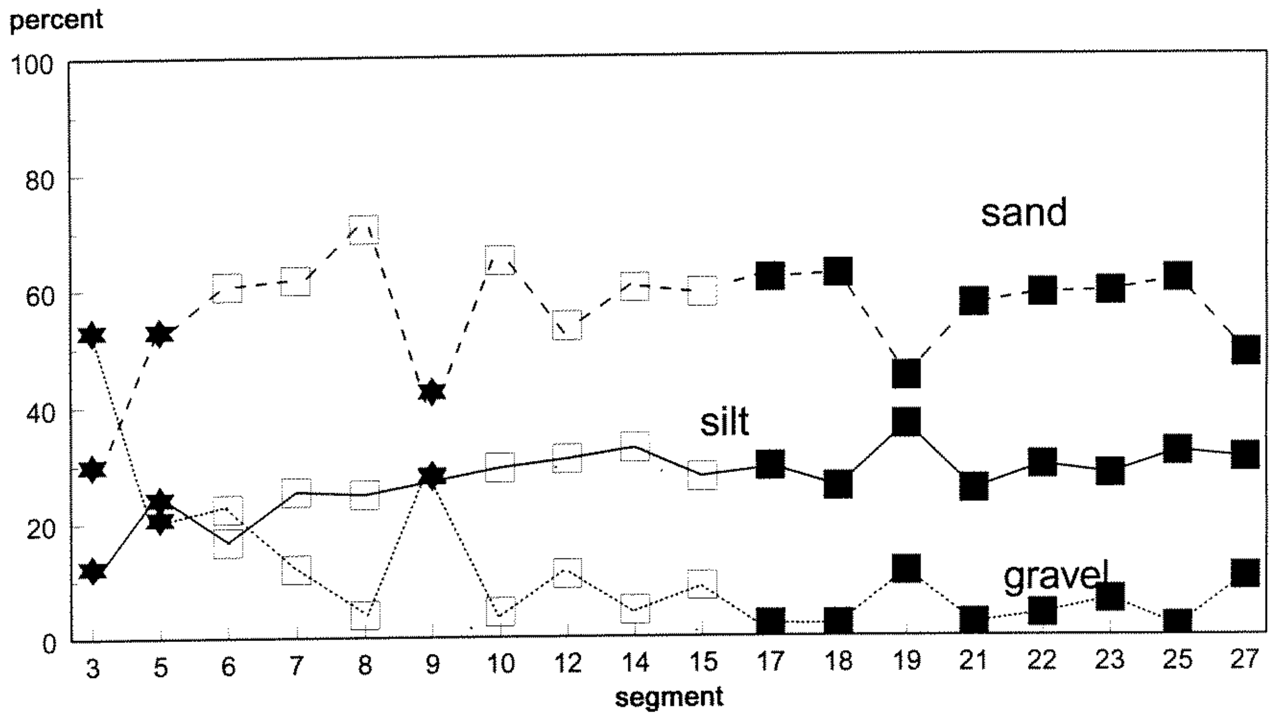


Figure 17. Average substrate percentages composed of silt (solid line), sand (long dashes), and gravel (short dashes) among 18 Missouri River study segments in 1996. Solid squares = channelized river segments, open squares = inter-reservoir segments, and stars = least-impacted river segments.

Table 11. Total numbers of all fishes collected in each Missouri and Lower Yellowstone River study segment in 1996. Columns in bold are segments immediately downstream of impoundments.

	STATE and SEGMENT																	
	MT					MT/ ND		ND	SD/NE		IA/NE			KS/MO			MO	
Taxa	3	5	**6**	7	8	9	10	**12**	**14**	**15**	*17*	*18*	*19*	*21*	*22*	*23*	*25*	*27*	Total
TARGET BENTHIC FISH																			
Pallid sturgeon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Shovelnose sturgeon	2	12	3	9	4	28	24	0	1	12	11	7	2	30	48	40	6	6	245
Common carp	14	22	0	1	5	7	9	21	54	93	25	15	22	49	23	31	39	51	481
Flathead chub	1337	121	0	5	67	1189	125	0	6	0	0	0	0	2	0	3	1	0	2,882
Sturgeon chub	0	43	0	5	37	230	11	0	0	0	2	1	6	3	1	3	1	1	344
Sicklefin chub	0	21	0	0	6	6	28	0	0	1	0	0	1	5	4	2	4	5	83
Emerald shiner	78	309	0	0	0	11	2	2	44	2197	119	166	663	203	241	162	182	16	4,395
Sand shiner	0	0	0	0	0	0	0	1	5	115	0	0	1	3	1	4	22	1	153
Hybognathus spp.	102	393	0	0	5	359	3	0	1	70	3	0	62	182	291	153	84	51	1,759
Fathead minnow	1	0	2	10	5	0	0	221	0	0	1	0	1	0	0	0	1	0	242
Blue sucker	2	2	1	0	0	2	1	3	0	3	1	3	0	3	3	7	0	0	31
Bigmouth buffalo	0	1	0	0	0	1	3	1	0	4	2	0	1	0	0	0	0	1	14
Smallmouth buffalo	22	3	1	0	3	4	4	0	5	3	0	0	0	1	3	5	2	4	60
River carpsucker	14	8	2	6	12	279	2	16	35	194	10	12	26	43	34	22	22	24	761
White sucker	35	0	19	103	93	0	2	137	0	0	0	0	0	0	0	0	0	0	389
Shorthead redhorse	82	35	1	0	5	2	3	5	8	52	1	0	0	1	0	0	0	0	195
Channel catfish	6	23	1	0	3	83	29	2	29	19	13	72	53	79	131	193	121	133	990
Blue catfish	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	8	57	23	103
Stonecat	3	1	0	1	0	22	14	0	1	1	1	0	0	0	0	0	0	0	44
Flathead catfish	0	0	0	0	0	0	0	0	0	30	27	82	127	94	40	34	46	55	535
Burbot	1	32	0	1	2	0	29	0	0	0	0	0	0	0	0	0	0	0	65
Walleye	0	5	2	0	2	1	0	16	15	6	0	0	2	1	0	1	1	0	52
Sauger	6	16	0	3	1	8	7	0	6	11	4	4	4	10	16	8	6	0	110
Freshwater drum	19	31	0	0	4	9	12	0	0	32	1	5	5	26	36	41	107	148	476
NON-TARGET FISH (exclusive of hybrids and introduced species)																			
Paddlefish	0	0	0	0	0	0	0	0	0	2	0	0	1	0	0	0	0	0	3
Spotted gar	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
Longnose gar	0	0	0	0	0	0	0	0	0	3	0	0	0	5	5	1	6	10	30
Shortnose gar	0	0	0	0	0	0	0	0	2	10	4	1	5	9	16	32	32	13	124
Goldeye	24	34	13	25	100	41	34	1	5	18	40	129	15	29	13	8	67	14	610
Gizzard shad	0	0	0	0	0	0	0	0	170	657	96	489	392	258	612	825	347	1141	4,987
Threadfin shad	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
Lake chub	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Red shiner	0	0	0	0	0	0	0	0	10	41	8	2	5	20	21	29	38	42	216
Spotfin shiner	0	0	0	0	0	0	0	0	71	21	0	3	83	1	1	0	0	0	180
Speckled chub	0	0	0	0	0	0	0	0	0	0	0	5	20	2	0	5	2	3	37
Silver chub	0	0	0	0	0	0	0	0	0	0	0	0	7	36	61	16	15	13	148
Golden shiner	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	3	0	0	4
River shiner	0	0	0	0	0	0	0	0	15	7	4	11	94	17	4	29	0	1	182
Ghost shiner	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Bigmouth shiner	0	0	0	0	0	0	0	0	0	4	1	0	0	1	0	0	0	0	6
Spottail shiner	36	86	119	4	4	0	0	1	0	6	0	1	0	0	0	0	0	0	257
Suckermouth minnow	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2
Northern redbelly dace	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1

Table 11. Continued.

Taxa	MT					MT/	ND	ND	SD/NE		IA/NE			KS/MO				MO	Total
	3	5	6	7	8	9	10	12	14	15	17	18	19	21	22	23	25	27	
NON-TARGET FISH (exclusive of hybrids and introduced species)																			
Bluntnose minnow	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	3
Bullhead minnow	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
Longnose dace	34	15	0	5	1	38	0	0	0	0	0	0	0	0	0	0	0	0	93
Creek chub	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	3
Quillback	0	0	0	0	0	0	0	0	2	30	3	1	0	0	1	0	0	0	37
Highfin carpsucker	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
Longnose sucker	5	1	8	4	10	3	1	74	0	0	0	0	0	0	0	0	0	0	106
Northern hogsucker	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
River redhorse	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	2
Black bullhead	0	0	0	0	0	0	0	0	0	0	2	0	0	1	0	0	0	0	3
Northern pike	8	16	10	6	14	6	31	6	2	2	0	0	1	1	0	0	0	0	103
Rainbow trout	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
Banded killifish	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	4
Brook silverside	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
Brook stickleback	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1
Mottled sculpin	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Rock bass	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	2
Green sunfish	0	0	0	0	0	4	1	0	6	4	1	0	2	5	4	1	1	2	32
Orangespotted sunfish	0	0	0	0	0	0	0	0	0	0	0	0	0	7	9	4	0	3	23
Bluegill	0	0	0	0	0	0	0	3	54	16	2	3	2	1	3	15	29	15	143
Longear sunfish	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
Smallmouth bass	0	0	1	0	0	0	0	19	36	52	1	0	0	0	0	0	0	0	109
Spotted bass	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	3	5
Largemouth bass	0	0	0	0	0	0	0	0	103	19	2	0	0	0	0	6	11	0	141
White crappie	15	11	0	1	37	20	60	0	764	12	1	4	10	2	2	0	9	4	952
Black crappie	0	17	0	0	0	0	3	1	9	3	0	0	2	0	0	0	0	0	35
Johnny darter	0	0	0	0	0	0	0	7	20	2	0	0	0	0	0	0	0	0	29
Yellow perch	0	33	0	0	2	0	0	13	62	18	0	0	0	0	0	0	0	0	128
INTRODUCED SPECIES (excluding common carp)																			
Grass carp	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	1	0	0	3
Bighead carp	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	2	3
Rainbow smelt	0	0	1	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	6
Ciscoe	0	0	11	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	13
Mosquitofish	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	3	2	7
White perch	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	2
White bass	0	0	0	0	0	0	0	1	0	83	0	7	6	18	10	16	2	4	147
Striped bass	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	7	12
HYBRIDS																			
Sauger x walleye	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1
Green sunfish x orangespotted s.f.	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1
UNIDENTIFIED (Unid.) SPECIES AND OTHERS																			
Larval fish	0	0	0	5	0	0	0	0	0	0	9	0	18	0	0	0	0	0	32
Unid. Age-0 fish	0	5	0	0	9	380	0	0	39	194	0	0	0	0	0	0	0	0	627
Unid. fish	0	7	0	0	0	3	0	0	0	0	2	0	0	0	0	0	0	0	12
Unid. *Lepomis*	0	0	0	0	0	0	0	3	2	1	0	0	0	0	0	0	0	0	6
Unid. *Stizostedion*	2	7	0	0	1	0	10	0	0	0	0	0	0	0	0	0	0	0	20
Unid. buffalo	15	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	17
Unid. carpsucker	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	2

Table 11. Continued.

Taxa	MT 3	5	6	7	8	MT/ND 9	ND 10	ND 12	SD/NE 14	15	IA/NE 17	18	19	KS/MO 21	22	23	25	MO 27	Total
									UNIDENTIFIED (Unid.) SPECIES AND OTHERS										
Unid. minnow	3	24	**5**	1	5	185	13	**22**	**0**	**0**	4	0	51	0	0	0	0	0	313
Unid. redhorse	0	0	**0**	0	0	0	0	**0**	**0**	**0**	2	0	0	0	0	0	0	0	2
Unid. shiner	0	0	**0**	0	0	0	0	**0**	**42**	**41**	0	0	7	0	0	0	0	0	90
Unid. sucker	131	2	**2**	4	4	337	1	**442**	**27**	**245**	0	0	0	0	0	0	0	0	1,195
Unid. sunfish	0	0	**0**	0	0	0	0	**0**	**14**	**0**	0	0	0	0	0	0	0	0	14
Species richness	24	27	**16**	16	22	26	24	**26**	**30**	**40**	31	23	34	36	29	34	34	33	78

Table 12. The five numerically dominant fish taxa, expressed as the percentage of total catch within each Missouri and Lower Yellowstone River study section in 1996. Species in **bold** are target benthic taxa.

Section	Description and states	Taxa (%)	Total percent of section
1	Missouri River Headwater mainstem (Montana)	**Flathead chub** (44 %) ***Hybognathus* spp**. (15 %) **Emerald shiner** (12 %) Unidentified sucker (4 %) Spottail shiner (4 %)	79 %
2	Upper Inter-Reservoir I (Montana)	**White sucker** (29 %) Goldeye (19 %) Spottail shiner (17 %) **Flathead chub** (10 %) **Sturgeon chub** (6 %)	81 %
3	Yellowstone River (Montana)	**Flathead chub** (36 %) Unidentified age-0 fish (12 %) ***Hybognathus* spp.** (11 %) Unidentified sucker (10 %) **River carpsucker** (9 %)	78 %
4	Upper Inter-Reservoir II (North Dakota)	**Flathead chub** (27 %) White crappie (13 %) Goldeye (7 %) Northern pike (7 %) **Channel catfish and Burbot** (6 % each)	66 %
5	Upper Inter-Reservoir III (North Dakota)	Unidentified sucker (43 %) **Fathead minnow** (21 %) **White sucker** (13 %) Longnose sucker (7 %) Unidentified minnow (2 %)	86 %
6	Inter-Reservoir IV and Unchannelized Area (South Dakota)	**Emerald shiner** (37 %) Gizzard shad (14 %) White crappie (13 %) Unidentified sucker (5 %) Unidentified age-0 fish (4 %)	73 %

Table 12. Continued.

Section	Description and states	Taxa (%)	Total percent of section
7	Channelized I (Iowa/Nebraska)	Gizzard shad (32 %) **Emerald shiner** (31 %) **Flathead catfish** (8 %) Goldeye (6 %) **Channel catfish** (5 %)	82 %
8	Channelized II (Kansas/Missouri)	Gizzard shad (38 %) ***Hybognathus* spp.** (14 %) **Emerald shiner** (13 %) **Channel catfish** (9 %) **Flathead catfish** (4 %)	78 %
9	Channelized III (Missouri)	Gizzard shad (48 %) **Freshwater drum** (8 %) **Channel catfish** (8 %) **Emerald shiner** (6 %) ***Hybognathus* spp.** (4 %)	74 %

Population structure and habitat use of benthic taxa

A general format for population structure and habitat use of each target taxa includes a brief paragraph summarizing results and a Table and Figure of relative abundance data among segments and macrohabitats, followed by habitat use (physicochemical characteristics), and size structure Figures. This format provides the reader with access to system-wide information about a particular species in one area of the report. Relative abundance figures generally have a standardized range for the y-axis (i.e., catch-per-unit-effort axis) to facilitate comparisons among macrohabitats. Habitat use Figures are the frequency of occurrence of each taxa plotted against intervals of depth, velocity, turbidity, and water temperature. Frequency of occurrence among depth, velocity, turbidity, and water temperature intervals are based only on depths, velocities, turbidities, and water temperatures measured at taxa specific collection sites. Size structure figures are the frequency of occurrence of each taxa's individuals plotted against species specific length intervals. Size structures are presented by study section.

Shovelnose sturgeon (SNSG)

Two-hundred-forty-five shovelnose sturgeon were captured in all segments, except **12**, with all gears except the bag seine (Figure 18; Tables 13 and 14). They were collected in CHXOs, OSBs, ISB-CHNBs, ISB-POOLs, SCN, SCC-DEEP, TRM-SMLL, and TRM-LRGE. Most were captured in continuous macrohabitats (OSBs, ISBs, CHXOs) and SCC, and few were collected in SCN and TRMs. Inside bend-channel borders appear to be used as a common meso-habitat throughout the river, based on drifting trammel net catches. Electrofishing was an ineffective gear for sampling shovelnose sturgeon in 1996 as they were only collected with this gear in segment *17* in an ISB-POOL (a non-standardized procedure). However, ISB-POOLs were not present or sampled in segments upstream of *17*. Also, the segment **6** SCN catch rate data (Figure 18) are from dredge cut pools below Fort Peck Dam, MT. In upper segments (3-**15**) most shovelnose sturgeon were collected in CHXOs and OSBs. However, in lower river segments (*17-27*) most were collected in ISBs and SCC.

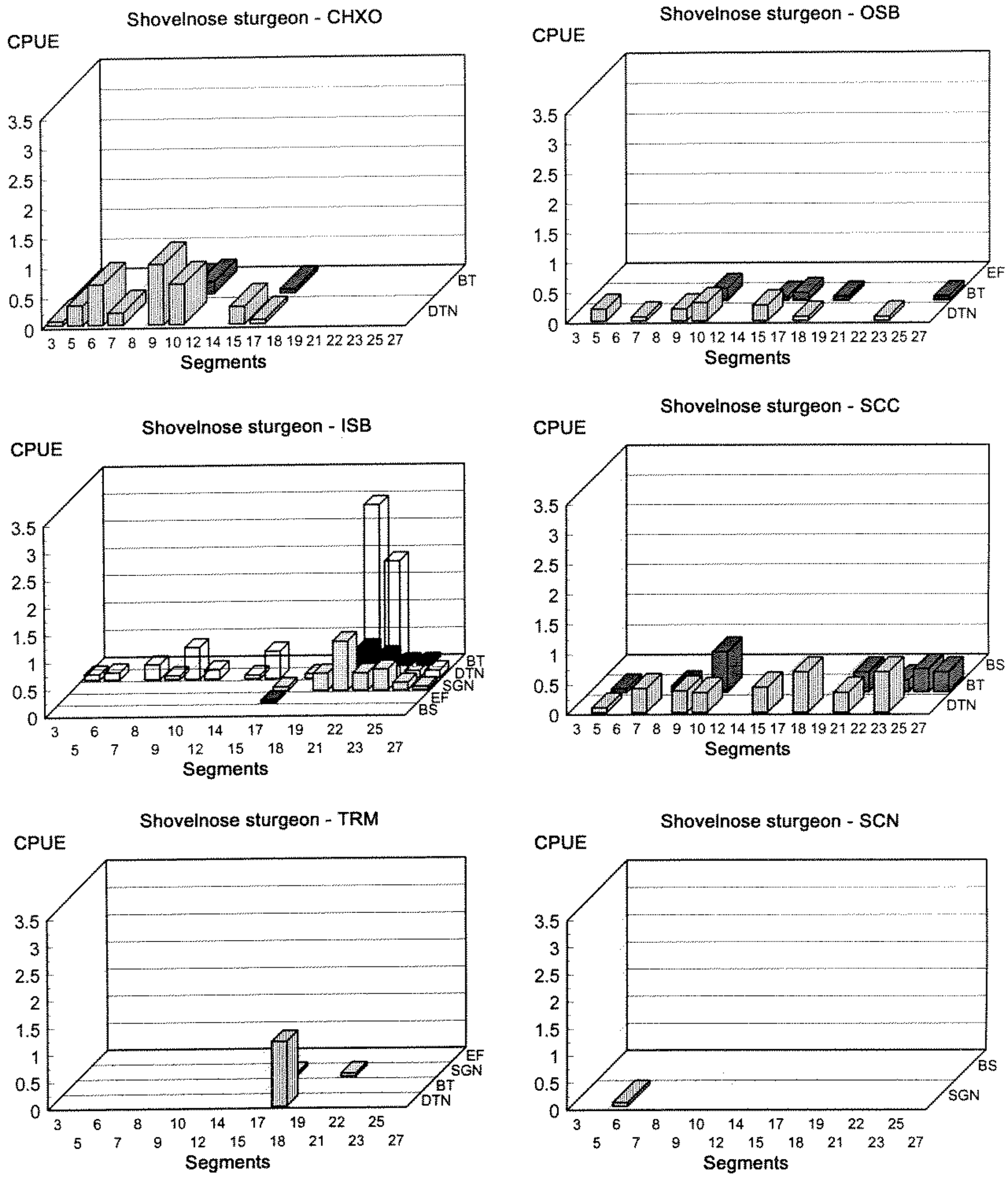


Figure 18. Trends of shovelnose sturgeon catch rates among Missouri River study segments and macrohabitats in 1996. Catch rates for a benthic trawl (BT) and drifting trammel net (DTN) are #/100 m, for a bag seine (BS) - #/180 degree haul, experimental gill net (SGN) - #/hr, and electrofishing (EF) - #/min. See Appendix A for macrohabitat acronyms.

Table 13. Relative abundance of shovelnose sturgeon collected in 18 Missouri River study segments in continuous macrohabitats (channel crossover-CHXO; outside bend-OSB; and inside bend-ISB) during 1996. Relative abundance in the various gears are #/100 m in drifting trammel nets (DTN) and a benthic trawl (BT); #/hr in stationary gill nets (SGN); #/min with boat electrofishing (EF); and #/180 degree shoreline haul with a bag seine (BS). A "-" indicates not sampled.

	CHXO		OSB			ISB				
Segment	BT	DTN	EF	BT	DTN	BS	SGN	EF	BT	DTN
3	-	0.07	0.00	-	0.00	0.00	-	-	-	0.10
5	0.00	0.33	0.00	0.00	0.20	0.00	-	0.00	0.00	0.13
6	0.00	0.67	-	-	-	0.00	-	-	-	-
7	0.00	0.20	-	0.00	0.07	0.00	-	-	0.00	0.27
8	0.07	0.00	-	0.00	0.00	0.00	0.00	-	0.00	0.07
9	0.13	1.00	-	0.00	0.20	0.00	0.00	-	0.00	0.58
10	0.20	0.67	0.00	0.20	0.30	0.00	-	-	0.00	0.17
12	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	0.07
15	0.00	0.29	0.00	0.07	0.26	0.00	-	-	0.00	0.50
17	0.07	0.07	0.00	0.13	0.00	0.00	0.07	0.05	0.00	0.00
18	0.00	0.00	0.00	0.00	0.07	-	0.00	0.00	0.00	0.08
19	0.00	0.00	0.00	0.07	0.00	-	0.31	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.89	0.00	0.33	0.20
22	0.00	0.00	0.00	0.00	0.00	0.00	0.31	0.00	0.20	3.17
23	0.00	0.00	0.00	0.00	0.07	0.00	0.38	0.00	0.07	2.13
25	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.00	0.07	0.13
27	0.00	0.00	0.00	0.07	0.00	0.00	0.06	0.00	0.00	0.13

Table 14. Relative abundance of shovelnose sturgeon collected in 18 Missouri River study segments in discrete macrohabitats (secondary channels connected-SCC; secondary channels non-connected-SCN; and tributary mouths-TRM) during 1996. Relative abundance in the various gears are #/100 m in drifting trammel nets (DTN) and a benthic trawl (BT); #/hr in stationary gill nets (SGN); #/min with boat electrofishing (EF); and #/180 degree shoreline haul with a bag seine (BS). A "-" indicates not sampled.

	SCC			SCN		TRM			
Segment	BT	DTN	BS	SGN	BS	EF	SGN	BT	DTN
3	-	-	0.00	-	-	-	-	-	-
5	0.06	0.08	0.00	0.00	0.00	-	-	-	-
6	-	-	0.00	0.07	0.00	-	0.00	-	-
7	0.00	0.40	0.00	0.00	0.00	-	0.00	-	-
8	0.11	0.00	0.00	0.00	0.00	-	0.00	-	-
9	0.00	0.36	0.00	0.00	0.00	-	-	-	-
10	0.67	0.33	0.00	0.00	0.00	-	-	-	-
12	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	-	-
15	0.00	0.42	0.00	0.00	0.00	0.00	0.00	-	-
17	-	-	-	-	-	0.00	0.06	-	0.00
18	0.00	0.67	-	-	-	0.00	0.00	0.00	1.20
19	0.00	-	0.00	-	-	0.00	0.00	-	0.00
21	0.33	0.33	-	-	-	0.00	0.06	0.00	0.00
22	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.20	0.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	0.33	0.00	0.00	0.00	0.00	0.00	0.00	-	-

Most shovelnose sturgeon were collected in moderate depths (50% of all individuals in depths between 2 and 4 m), moderate velocities (30% in velocities between 0.6 and 0.8 m/s), and moderate turbidities (45% in tubidities between 50 and 100 NTUs) (Figure 19). Only 15% of shovelnose sturgeon were collected in depths < 2 m and fewer than 5% were collected in velocities < 1.4 m/s. Also, most shovelnose sturgeon (58%) were collected in warmer water temperatures (i.e., 24-28 °C).

Shovelnose sturgeon fork lengths varied between 0-50 and 750-800 mm length intervals with most > 350 mm (Figure 20). Shovelnose sturgeon < 350 mm long were only captured in sections 3 (Yellowstone River), **4** (Yellowstone River confluence to Lake Sakakawea headwaters), and *8* and *9* (Channelized Missouri River downstream of Rulo, NE). Shovelnose sturgeon < 50 mm, which were likely age-0 fish (Pflieger 1975) and successfully recruited to the gear, were only collected in section *9*.

Common carp (CARP)

Common carp were frequently collected in all segments, except **6**. Four-hundred-eighty-one fish were collected in all macro- and meso-habitats including a WILD (i.e., cattail dominated backwaters) in segment **14**. In general, most were captured in SCN and TRMs (Figure 21; Tables 15 and 16). In channelized segments (*17-27*) most carp were collected in ISBs, OSBs, and TRMs. Higher numbers were collected in SCN in inter-reservoir segments (**6-8, 10-15**). The benthic trawl collected few common carp and only in TRM-LRGE in segments *21* and *25*. Conversely, electrofishing captured many common carp in all segments where it was used (i.e., not used in areas with known pallid sturgeon populations like sections **2** and 3) except segment 3.

Common carp were generally collected in shallow depths, slow velocities, low-moderate turbidities (10-100 NTUs) and warm water temperatures (20-28 °C) (Figure 22). Ninety percent of common carp were collected in depths < 2 m and velocities < 0.6 m/s. Few common carp were collected in clear (< 10 NTUs) or extremely turbid (500 to 1000 NTUs) waters and none in water temperatures < 12 °C.

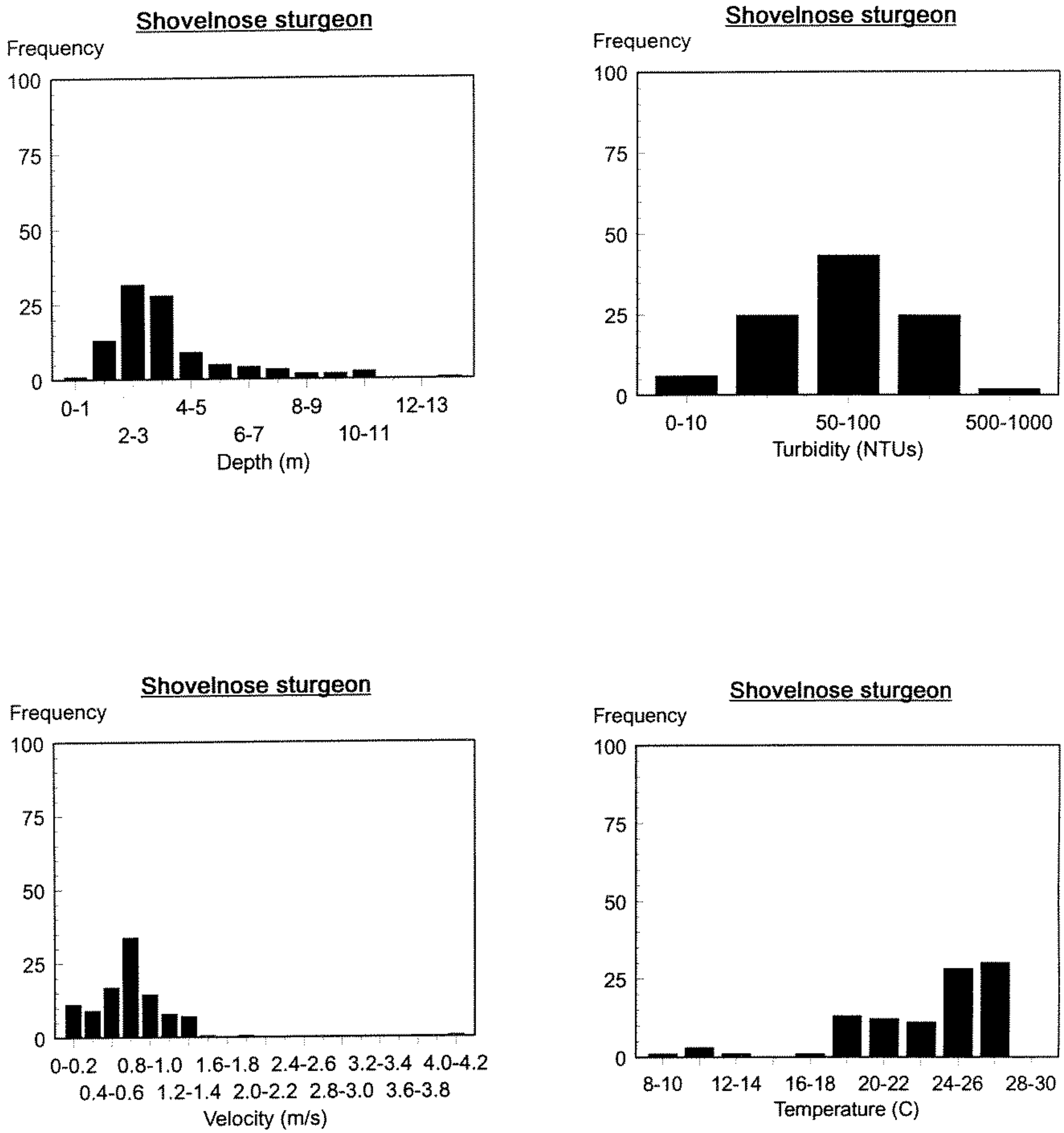


Figure 19. Frequency of occurrence of shovelnose sturgeon (N=240) in various depth, velocity, turbidity, and water temperature intervals from Missouri and Lower Yellowstone River collections in 1996.

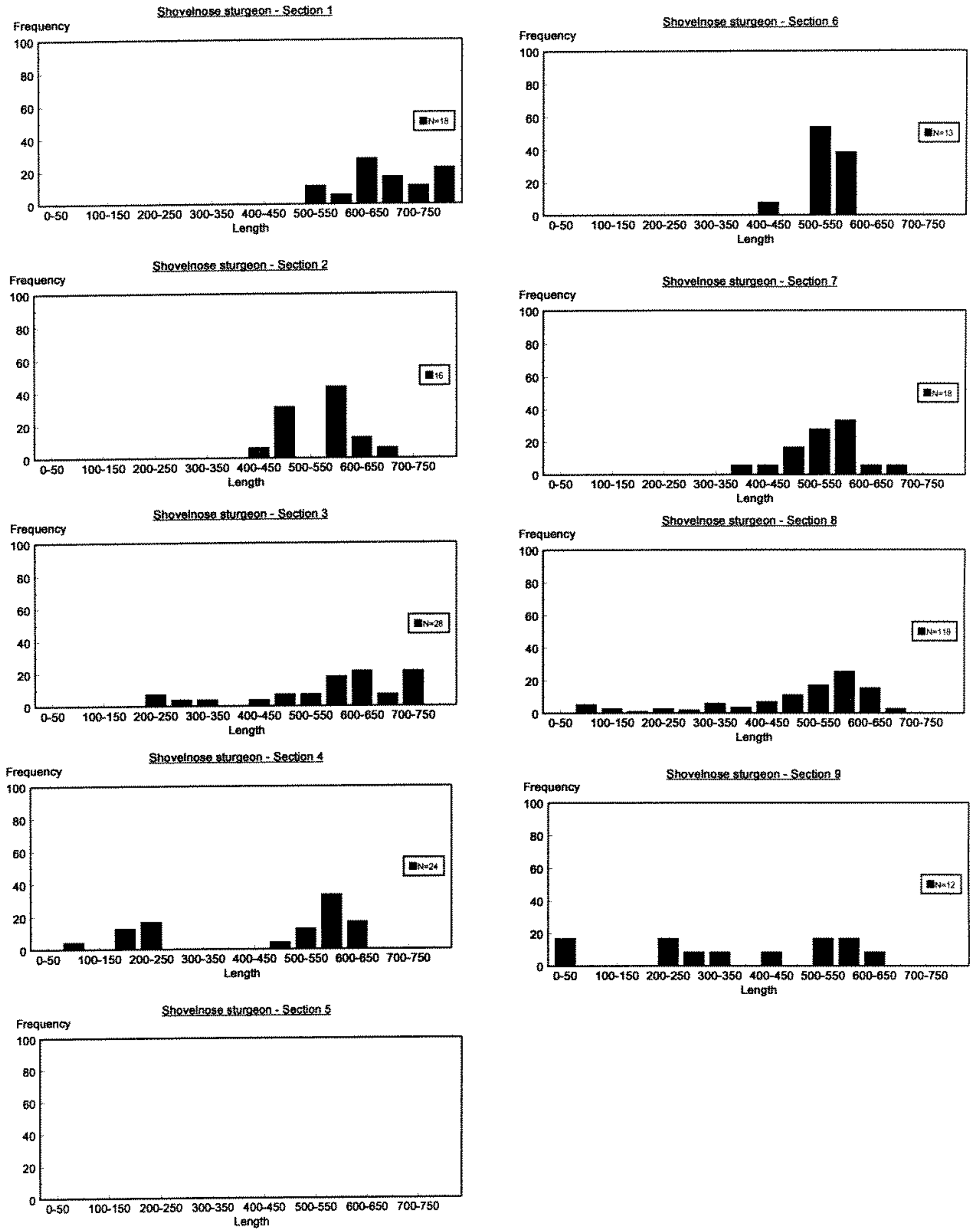


Figure 20. Length-frequency histograms of shovelnose sturgeon collected in Missouri River study sections during 1996 by drifting trammel nets, experimental gill nets, a benthic trawl, bag seine, and boat electrofishing.

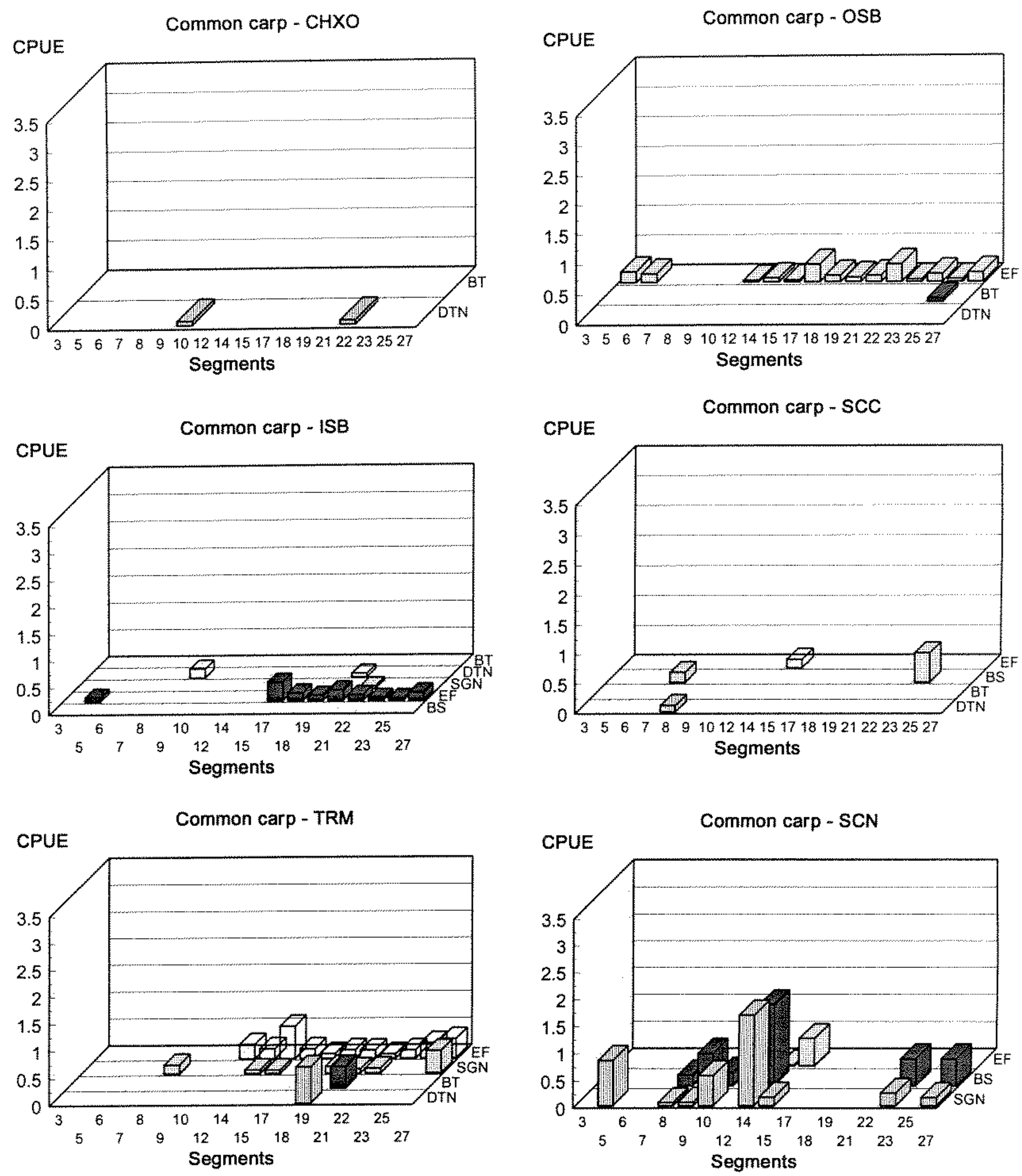


Figure 21. Trends of common carp catch rates among Missouri River study segments and macrohabitats in 1996. Catch rates for a benthic trawl (BT) and drifting trammel net (DTN) are #/100 m, for a bag seine (BS) - #/180 degree haul, experimental gill net (SGN) - #/hr, and electrofishing (EF) - #/min. See Appendix A for macrohabitat acronyms.

Table 15. Relative abundance of common carp collected in 18 Missouri River study segments in continuous macrohabitats (channel crossover-CHXO; outside bend-OSB; and inside bend-ISB) during 1996. Relative abundance in the various gears are #/100 m in drifting trammel nets (DTN) and a benthic trawl (BT); #/hr in stationary gill nets (SGN); #/min with boat electrofishing (EF); and #/180 degree shoreline haul with a bag seine (BS). A "-" indicates not sampled.

	CHXO		OSB			ISB				
Segment	BT	DTN	EF	BT	DTN	BS	SGN	EF	BT	DTN
3	-	0.00	0.18	-	0.00	0.00	-	-	-	0.00
5	0.00	0.00	0.15	0.00	0.00	0.00	-	0.08	0.00	0.00
6	0.00	0.00	-	-	-	0.00	-	-	-	-
7	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
9	0.00	0.00	-	0.00	0.00	0.00	0.00	-	0.00	0.17
10	0.00	0.07	0.03	0.00	0.00	0.00	-	-	0.00	0.00
12	0.00	0.00	0.07	0.00	0.00	0.00	-	-	-	-
14	0.00	0.00	0.03	0.00	0.00	-	-	-	0.00	0.00
15	0.00	0.00	0.29	0.00	0.00	0.00	-	-	0.00	0.00
17	0.00	0.00	0.11	0.00	0.00	0.00	0.00	0.35	0.00	0.00
18	0.00	0.00	0.08	0.00	0.00	-	0.00	0.15	0.00	0.00
19	0.00	0.00	0.11	0.00	0.00	-	0.00	0.10	0.00	0.00
21	0.00	0.00	0.29	0.00	0.00	0.00	0.00	0.20	0.00	0.07
22	0.00	0.07	0.05	0.00	0.00	0.00	0.05	0.11	0.00	0.00
23	0.00	0.00	0.13	0.00	0.00	0.00	0.00	0.06	0.00	0.00
25	0.00	0.00	0.05	0.07	0.00	0.00	0.00	0.05	0.00	0.00
27	0.00	0.00	0.16	0.00	0.00	0.00	0.00	0.16	0.00	0.00

Table 16. Relative abundance of common carp collected in 18 Missouri River study segments in discrete macrohabitats (secondary channels connected-SCC; secondary channels non-connected-SCN; tributary mouths-TRM) during 1996. Relative abundance in the various gears are #/100 m in drifting trammel nets (DTN) and a benthic trawl (BT); #/hr in stationary gill nets (SGN); #/min with boat electrofishing (EF); and #/180 degree shoreline haul with a bag seine (BS). A "-" indicates not sampled.

	SCC			SCN		TRM			
Segment	BT	DTN	BS	SGN	BS	EF	SGN	BT	DTN
3	-	-	0.00	-	-	-	-	-	-
5	0.00	0.00	0.00	0.83	0.00	-	-	-	-
6	-	-	0.00	0.00	0.00	-	0.00	-	-
7	0.00	0.00	0.17	0.00	0.00	-	0.00	-	-
8	0.00	0.11	0.00	0.06	0.20	-	0.17	-	-
9	0.00	0.00	0.00	0.07	0.60	-	-	-	-
10	0.00	0.00	0.00	0.56	0.25	-	-	-	-
12	0.00	0.00	0.00	0.00	0.00	0.27	0.00	-	-
14	0.00	0.00	0.00	1.67	1.50	0.18	0.07	-	-
15	0.00	0.00	0.00	0.16	0.00	0.60	0.07	-	-
17	-	-	-	-	-	0.18	0.00	-	0.00
18	0.00	0.00	-	-	-	0.09	0.00	0.00	0.00
19	0.00	-	0.00	-	-	0.16	0.13	-	0.67
21	0.00	0.00	-	-	-	0.15	0.08	0.40	0.00
22	-	-	0.00	0.00	0.00	0.07	0.09	0.00	0.00
23	0.00	0.00	0.50	0.24	0.50	0.15	0.00	0.00	0.00
25	0.00	0.00	0.00	0.00	0.00	0.28	0.00	0.00	0.00
27	0.00	0.00	0.00	0.15	0.50	0.36	0.42	-	-

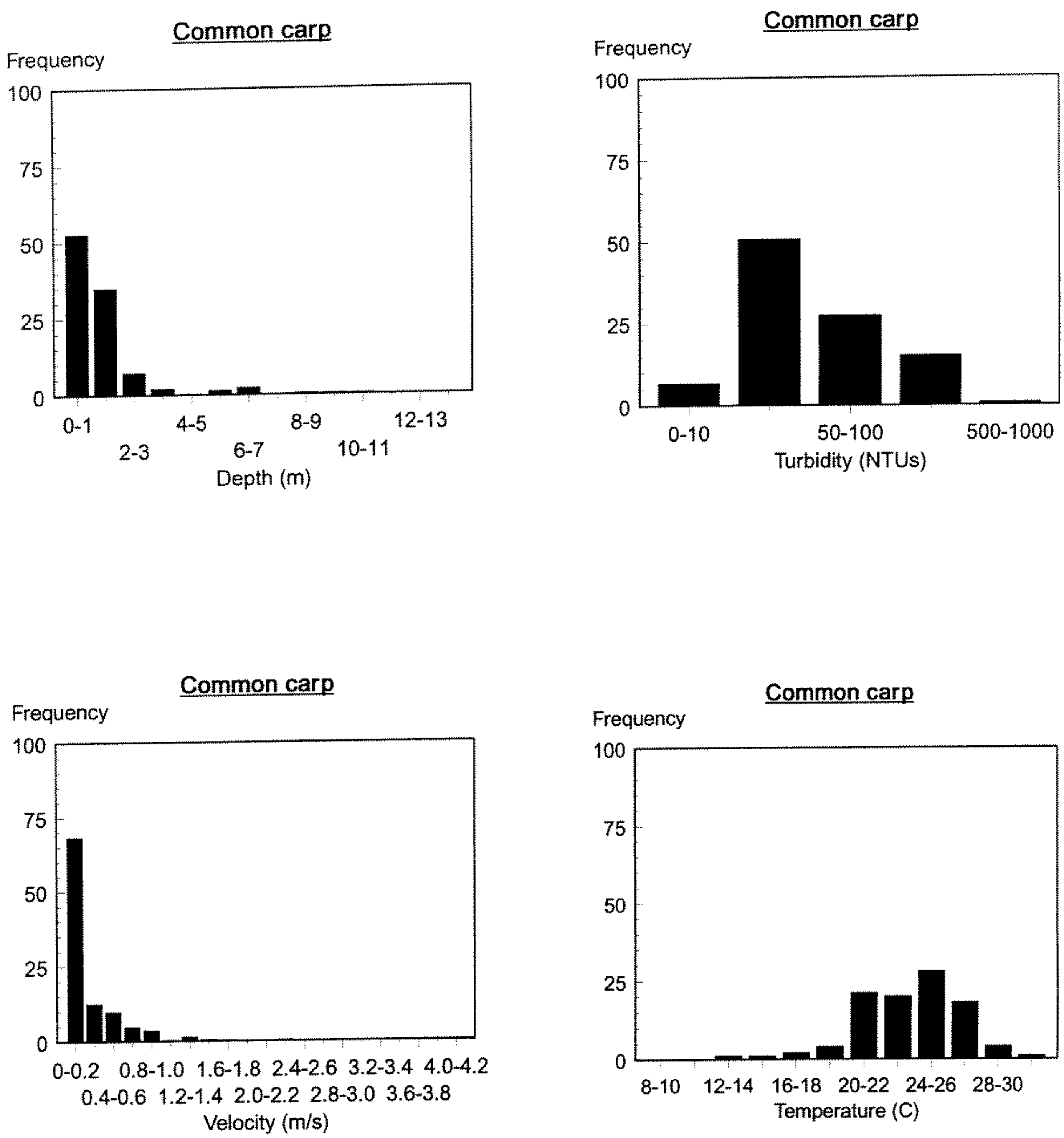


Figure 22. Frequency of occurrence of common carp (N=480) in various depth, velocity, turbidity, and water temperature intervals from Missouri and Lower Yellowstone River collections in 1996.

Common carp length distributions had a mode at 500 mm in most sections, and ranged between 0-50 and 700-750 mm length intervals (Figure 23). The largest common carp (712 mm) was captured in channelized section *9*. Natural reproduction as suggested by individuals < 50 mm long (Pflieger 1975) was evident in sections **2**, 3, **6**, *8*, and *9*.

Flathead chub (FHCB)

Two-thousand-eight-hundred and eighty-two flathead chubs were collected in 1996 in all macrohabitats except TRMs (Figure 24). They were abundant in least-impacted segments 3, 5, and 9, but rare in channelized segments (Tables 17 and 18). In least-impacted segments, most were collected in ISBs and SCC. No flathead chubs were collected in segments immediately downstream of impoundments (segments **6, 12, 14, 15**), except below Fort Randall Dam (segment **14**). However, these six individuals were collected in a TRM (i.e., the Niobrara River, NE). Ninty-two percent of flathead chubs were collected in least-impacted segments, 7% in inter-reservoir segments, and 1% in channelized segments.

Flathead chub were generally collected in shallow depths (97% in depths < 1 m) and slow velocities (91% in velocities < 0.4 m/s) (Figure 25). They were collected in turbidities ranging from 0 - 1000 NTUs with most (62%) in the 10-50 NTU range. Almost all flathead chubs (93%) were collected in water temperatures warmer than 20 °C.

Flathead chub ranged in length from 21-280 mm (Figure 26). A larger size structure (i.e., most > 81 mm) was apparent below Fort Peck Dam, MT (i.e., Missouri River study section **2**).

Sturgeon chub (SGCB)

Three-hundred-forty-four sturgeon chub were collected in all segments, except inter-reservoir segments **6, 12, 14,** and **15**, by bag seines and benthic trawls only (Figure 27; Tables 19 and 20). They were collected in all macrohabitats except TRMs and SCN. In order from greatest frequency of occurance, sturgeon chub were captured by bag seining in SCC-SHLW, ISB-BARS, and SCC-DEEP, and by benthic trawling in ISB-CHNBs, OSBs, CHXOs, and SCC-DEEP. Eighty percent of sturgeon chubs were collected in least-impacted segments 5,

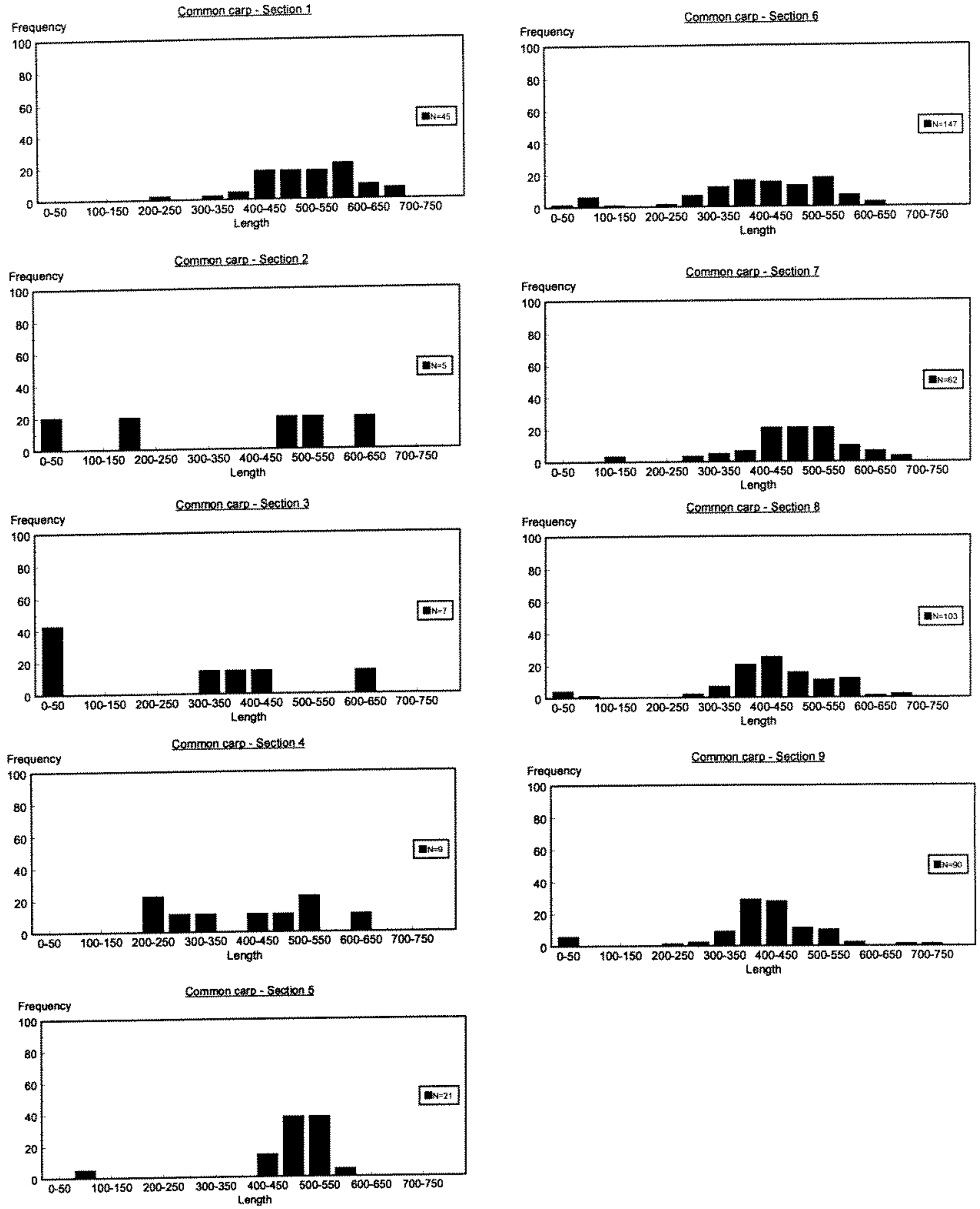


Figure 23. Length-frequency histograms of common carp collected in Missouri River study sections during 1996 by drifting trammel nets, experimental gill nets, a benthic trawl, bag seine, and boat electrofishing.

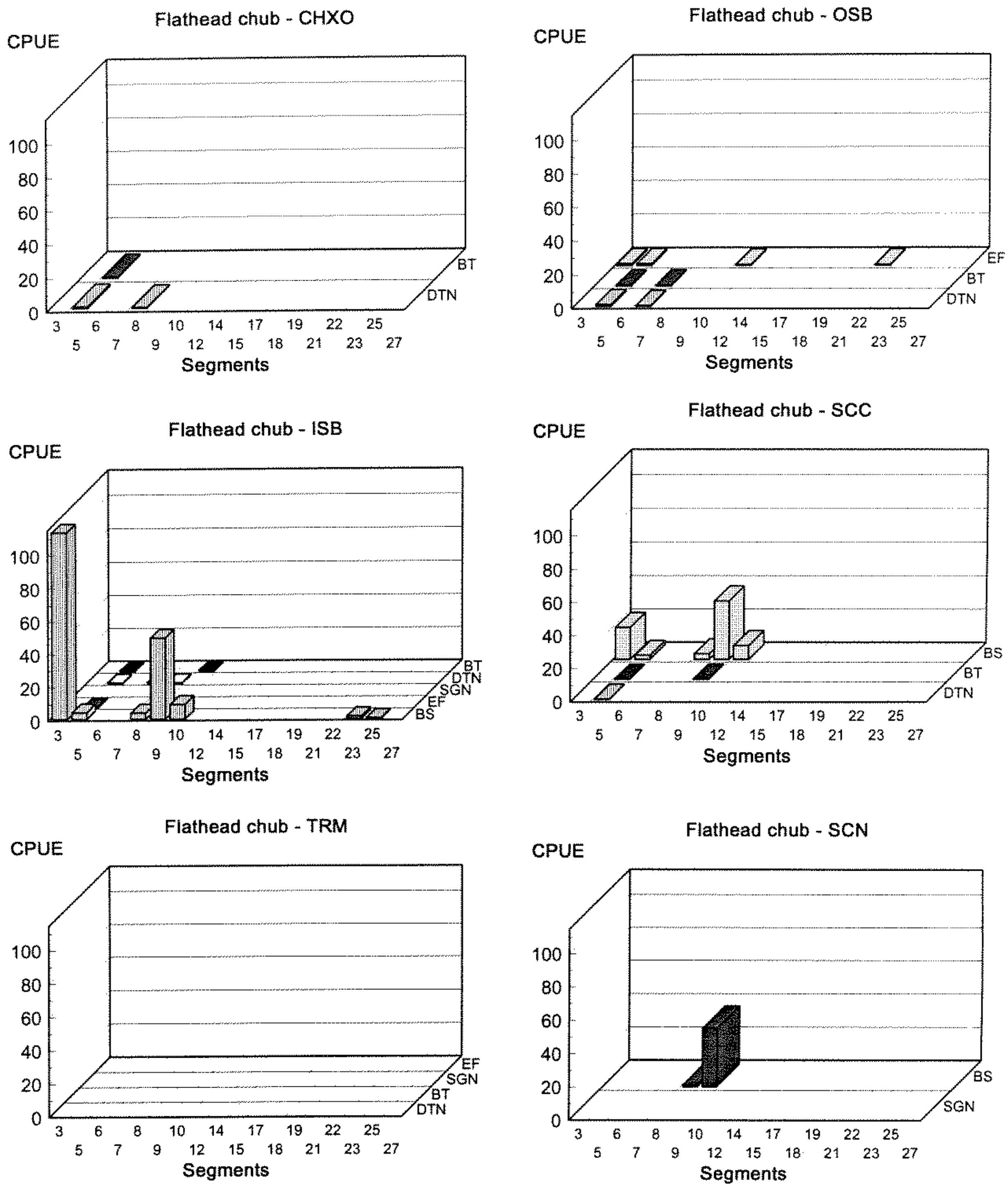


Figure 24. Trends of flathead chub catch rates among Missouri River study segments and macrohabitats in 1996. Catch rates for a benthic trawl (BT) and drifting trammel net (DTN) are #/100 m, for a bag seine (BS) - #/180 degree haul, experimental gill net (SGN) - #/hr, and electrofishing (EF) - #/min. See Appendix A for macrohabitat acronyms.

Table 17. Relative abundance of flathead chub collected in 18 Missouri River study segments in continuous macrohabitats (channel crossover-CHXO; outside bend-OSB; and inside bend-ISB) during 1996. Relative abundance in the various gears are #/100 m in drifting trammel nets (DTN) and a benthic trawl (BT); #/hr in stationary gill nets (SGN); #/min with boat electrofishing (EF); and #/180 degree shoreline haul with a bag seine (BS). A "-" indicates not sampled.

	CHXO		OSB			ISB				
Segment	BT	DTN	EF	BT	DTN	BS	SGN	EF	BT	DTN
3	-	0.00	0.21	-	0.00	112.7	-	-	-	0.00
5	0.07	0.13	0.31	0.13	0.27	4.10	-	0.51	0.38	0.07
6	0.00	0.00	-	-	-	0.00	-	-	-	-
7	0.00	0.00	-	0.07	0.20	0.00	-	-	0.00	0.07
8	0.00	0.07	-	0.00	0.00	3.80	0.00	-	0.00	0.13
9	0.00	0.00	-	0.00	0.00	49.1	0.00	-	0.42	0.00
10	0.00	0.00	0.05	0.00	0.00	8.83	-	-	0.00	0.00
12	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
15	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
18	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
21	0.00	0.00	0.03	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
23	0.00	0.00	0.00	0.00	0.00	1.50	0.00	0.00	0.00	0.00
25	0.00	0.00	0.00	0.00	0.00	0.10	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

Table 18. Relative abundance of flathead chub collected in 18 Missouri River study segments in discrete macrohabitats (secondary channels connected-SCC; secondary channels non-connected-SCN; tributary mouths-TRM) during 1996. Relative abundance in the various gears are #/100 m in drifting trammel nets (DTN) and a benthic trawl (BT); #/hr in stationary gill nets (SGN); #/min with boat electrofishing (EF); and #/180 degree shoreline haul with a bag seine (BS). A "-" indicates not sampled.

	SCC			SCN		TRM			
Segment	BT	DTN	BS	SGN	BS	EF	SGN	BT	DTN
3	-	-	19.40	-	-	-	-	-	-
5	0.08	0.17	2.50	0.00	0.00	-	-	-	-
6	-	-	0.00	0.00	0.00	-	0.00	-	-
7	0.00	0.00	0.00	0.00	0.00	-	0.00	-	-
8	0.00	0.00	3.50	0.00	1.00	-	0.00	-	-
9	0.33	0.00	35.20	0.00	34.80	-	-	-	-
10	0.00	0.00	8.50	0.00	0.00	-	-	-	-
12	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	-	-
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-
17	-	-	-	-	-	0.00	0.00	-	0.00
18	0.00	0.00	-	-	-	0.00	0.00	0.00	0.00
19	0.00	-	0.00	-	-	0.00	0.00	-	0.00
21	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
23	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
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-

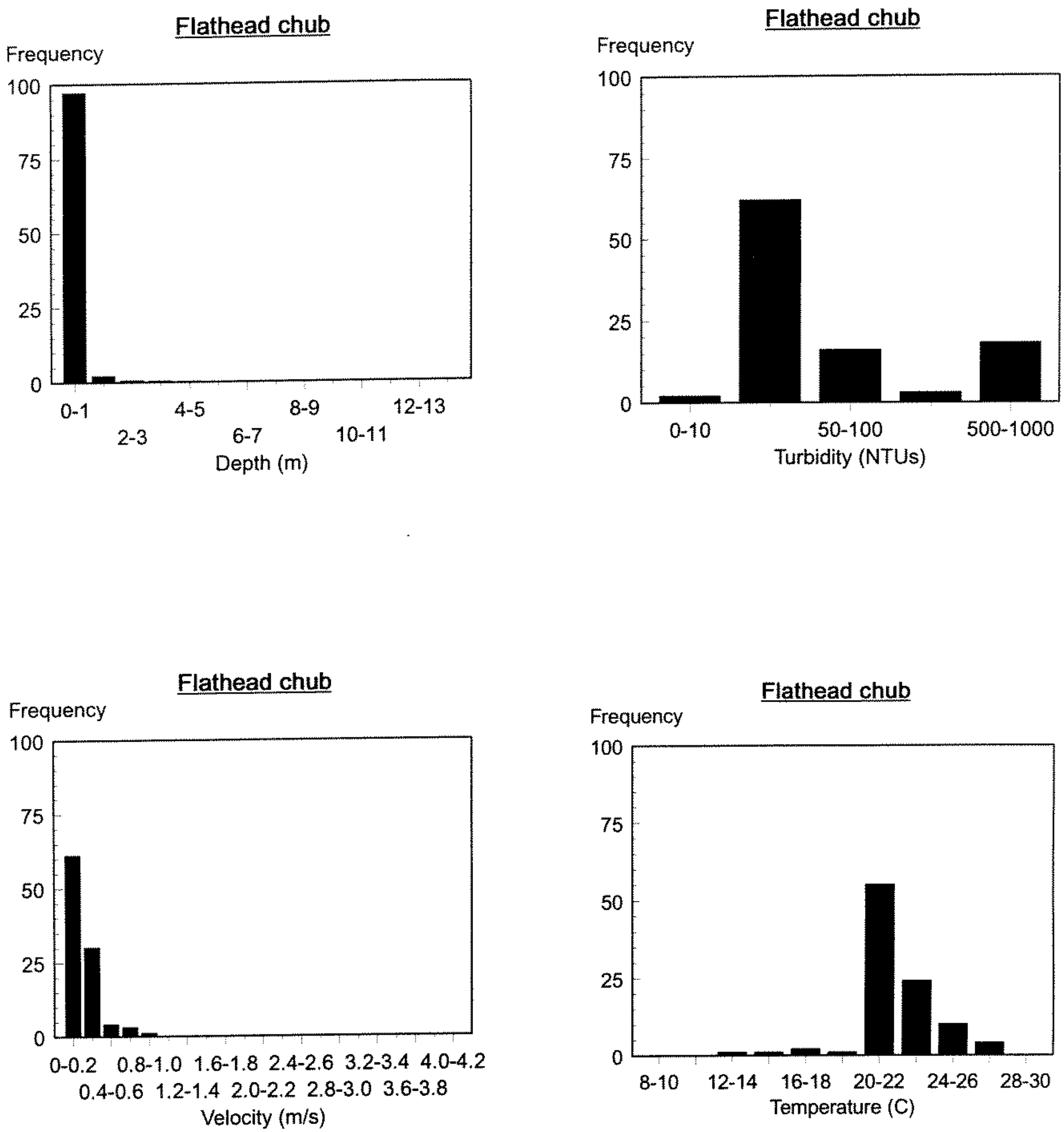


Figure 25. Frequency of occurrence flathead chubs (N=2,871) in various depth, velocity, turbidity, and water temperature intervals from Missouri and Lower Yellowstone River collections in 1996.

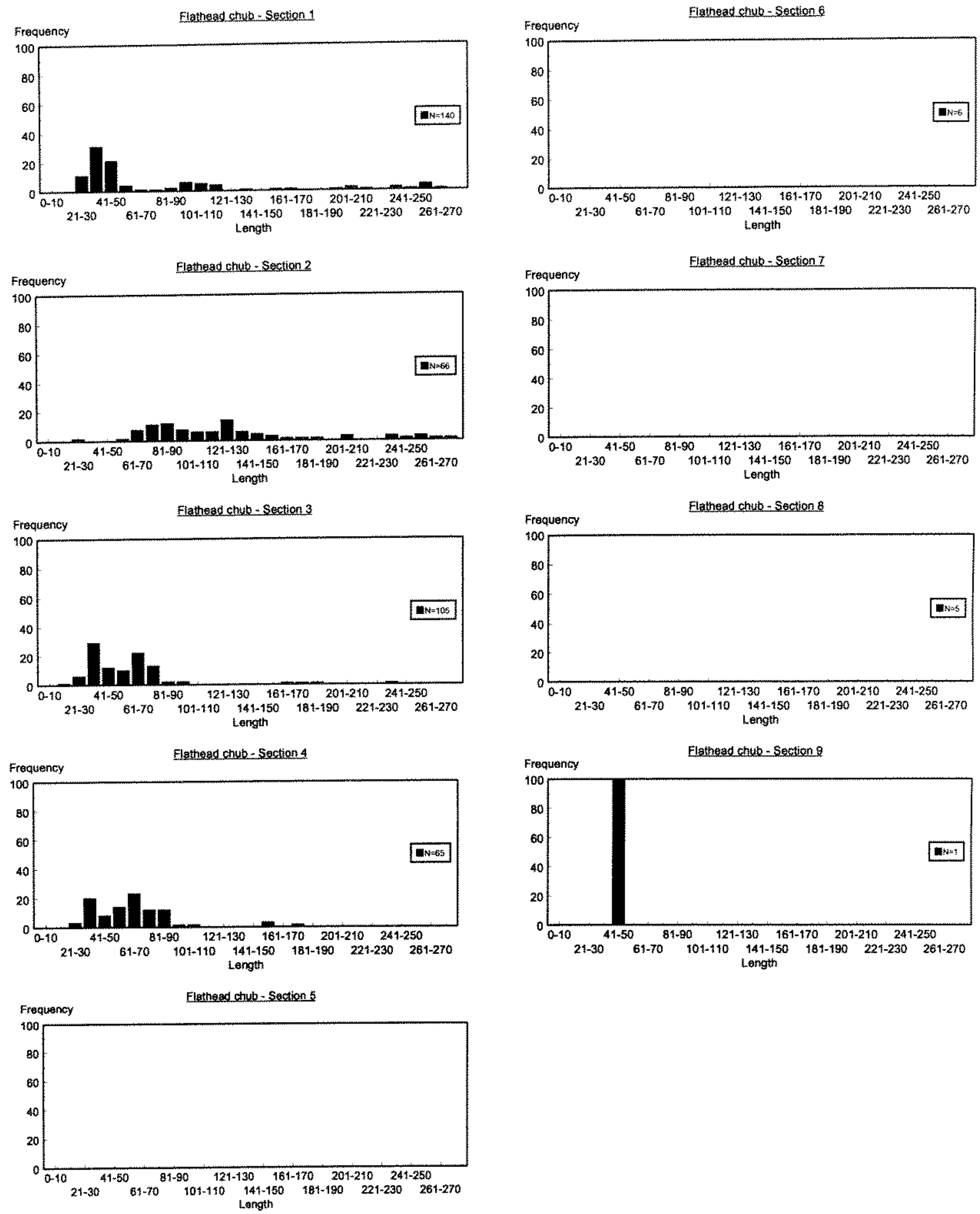


Figure 26. Length-frequency histograms of flathead chub collected in Missouri River study sections during 1996 by drifting trammel nets, experimental gill nets, a benthic trawl, bag seine, and boat electrofishing. Some lengths not presented as individuals were sent for age and growth analyses.

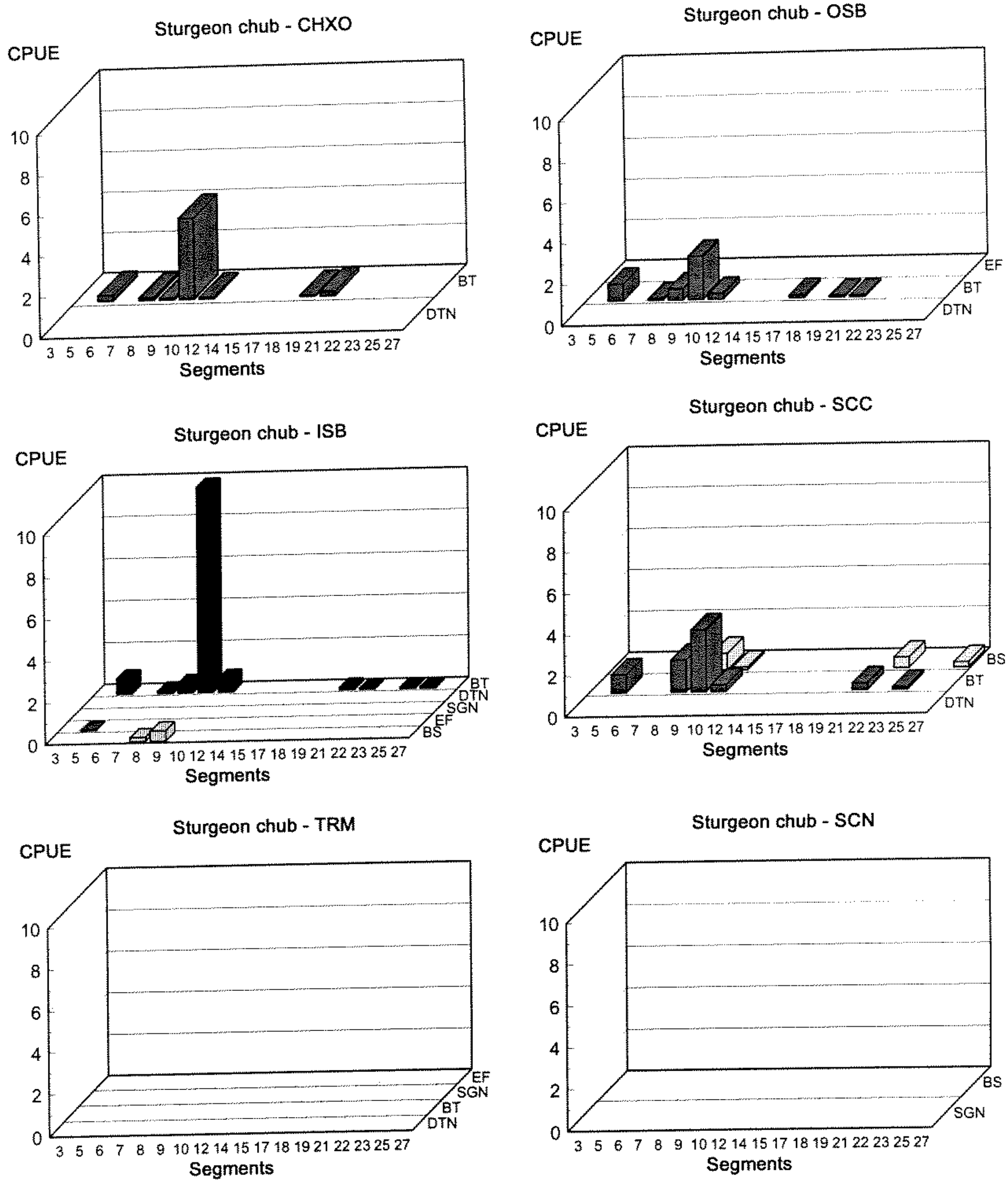


Figure 27. Trends of sturgeon chub catch rates among Missouri River study segments and macrohabitats in 1996. Catch rates for a benthic trawl (BT) and drifting trammel net (DTN) are #/100 m, for a bag seine (BS) - #/180 degree haul, experimental gill net (SGN) - #/hr, and electrofishing (EF) - #/min. See Appendix A for macrohabitat acronyms.

Table 19. Relative abundance of sturgeon chub collected in 18 Missouri River study segments in continuous macrohabitats (channel crossover-CHXO; outside bend-OSB; and inside bend-ISB) during 1996. Relative abundance in the various gears are #/100 m in drifting trammel nets (DTN) and a benthic trawl (BT); #/hr in stationary gill nets (SGN); #/min with boat electrofishing (EF); and #/180 degree shoreline haul with a bag seine (BS). A "-" indicates not sampled.

	CHXO		OSB			ISB				
Segment	BT	DTN	EF	BT	DTN	BS	SGN	EF	BT	DTN
3	-	0.00	0.00	-	0.00	0.00	-	-	-	0.00
5	0.27	0.00	0.00	0.80	0.00	0.00	-	0.01	0.75	0.00
6	0.00	0.00	-	-	-	0.00	-	-	-	-
7	0.13	0.00	-	0.07	0.00	0.00	-	-	0.13	0.00
8	0.07	0.00	-	0.53	0.00	0.20	0.00	-	0.47	0.00
9	4.00	0.00	-	2.11	0.00	0.50	0.00	-	9.83	0.00
10	0.07	0.00	0.00	0.27	0.00	0.00	-	-	0.67	0.00
12	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
15	0.00	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00
17	0.00	0.00	0.00	0.13	0.00	0.00	0.00	0.00	0.00	0.00
18	0.07	0.00	0.00	0.00	0.00	-	0.00	0.00	0.00	0.00
19	0.20	0.00	0.00	0.07	0.00	-	0.00	0.00	0.13	0.00
21	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.07	0.00
22	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	0.07	0.00
25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.00
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 20. Relative abundance of sturgeon chub collected in 18 Missouri River study segments in discrete macrohabitats (secondary channels connected-SCC; secondary channels non-connected-SCN; tributary mouths-TRM) during 1996. Relative abundance in the various gears are #/100 m in drifting trammel nets (DTN) and a benthic trawl (BT); #/hr in stationary gill nets (SGN); #/min with boat electrofishing (EF); and #/180 degree shoreline haul with a bag seine (BS). A "-" indicates not sampled.

	SCC			SCN		TRM			
Segment	BT	DTN	BS	SGN	BS	EF	SGN	BT	DTN
3	-	-	0.00	-	-	-	-	-	-
5	0.88	0.00	0.00	0.00	0.00	-	-	-	-
6	-	-	0.00	0.00	0.00	-	0.00	-	-
7	0.00	0.00	0.00	0.00	0.00	-	0.00	-	-
8	1.56	0.00	0.00	0.00	0.00	-	0.00	-	-
9	3.00	0.00	0.80	0.00	0.00	-	-	-	-
10	0.33	0.00	0.13	0.00	0.00	-	-	-	-
12	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	-	-
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-
17	-	-	-	-	-	0.00	0.00	-	0.00
18	0.00	0.00	-	-	-	0.00	0.00	0.00	0.00
19	0.00	-	0.00	-	-	0.00	0.00	-	0.00
21	0.33	0.00	-	-	-	0.00	0.00	0.00	0.00
22	-	-	0.50	0.00	0.00	0.00	0.00	0.00	0.00
23	0.13	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
27	0.00	0.00	0.25	0.00	0.00	0.00	0.00	-	-

and 9, or 12% of the river miles sampled. Fourteen percent were collected in inter-reservoir segments **8** and **10** which are above and below the Yellowstone River (segment 9). They were not captured in other inter-reservoir segments, but 17 individuals (6%) were found in channelized segments, although these segments make up 51% of the river miles sampled.

Sturgeon chub were captured in depths from 0 to 9 m with most (55%) in depths between 2 and 3 m (Figure 28). This may be partly due to most sturgeon chub being collected in the benthic trawl which is used in depths generally greater than 1.2 m. Few sturgeon chub were in depths > 4 m. Most sturgeon chub (50%) were collected in velocities between 0.6 and 1.0 m/s. About 5% were collected in 3.6-3.8 m/s. All other sturgeon chub were captured in velocities < 2.0 m/s. Almost all sturgeon chub (about 95%) were collected in 10-100 NTU turbidities and 20-26 °C water temperatures.

Sturgeon chub ranged in size from 17 to 121 mm with most < 100 mm (Figure 29). Only in section *7* did sturgeon chub exceed 100 mm with 55% of the catch (n=9). Sections 3 and *8* had higher frequencies of sturgeon chub < 50 mm.

Sicklefin chub (SFCB)

Eighty-three sicklefin chubs were collected in CHXOs, OSBs, ISB-CHNBs, ISB-BARS, and SCC-DEEP in 1996. They were not captured in TRMs or SCN (Figure 30; Tables 21 and 22). The benthic trawl appeared to be a good collection gear as all sicklefin chubs except one were collected with it. They were captured in CHXOs, OSBs, ISBs, and SCC in least-impacted and inter-reservoir segments, but were absent from OSBs and CHXOs in channelized segments. The numbers of sicklefin chubs collected were nearly equally split among least-impacted (33%), inter-reservoir (42%), and channelized (25%) segments. However, most of the inter-reservoir individuals (80%) were captured between the Yellowstone River mouth and Lake Sakakawea headwaters in North Dakota (i.e., segment **10**). Only one sicklefin chub was collected in segments immediately downstream of impoundments. That individual was collected in the unchannelized segment below Gavins Point Dam, SD/NE.

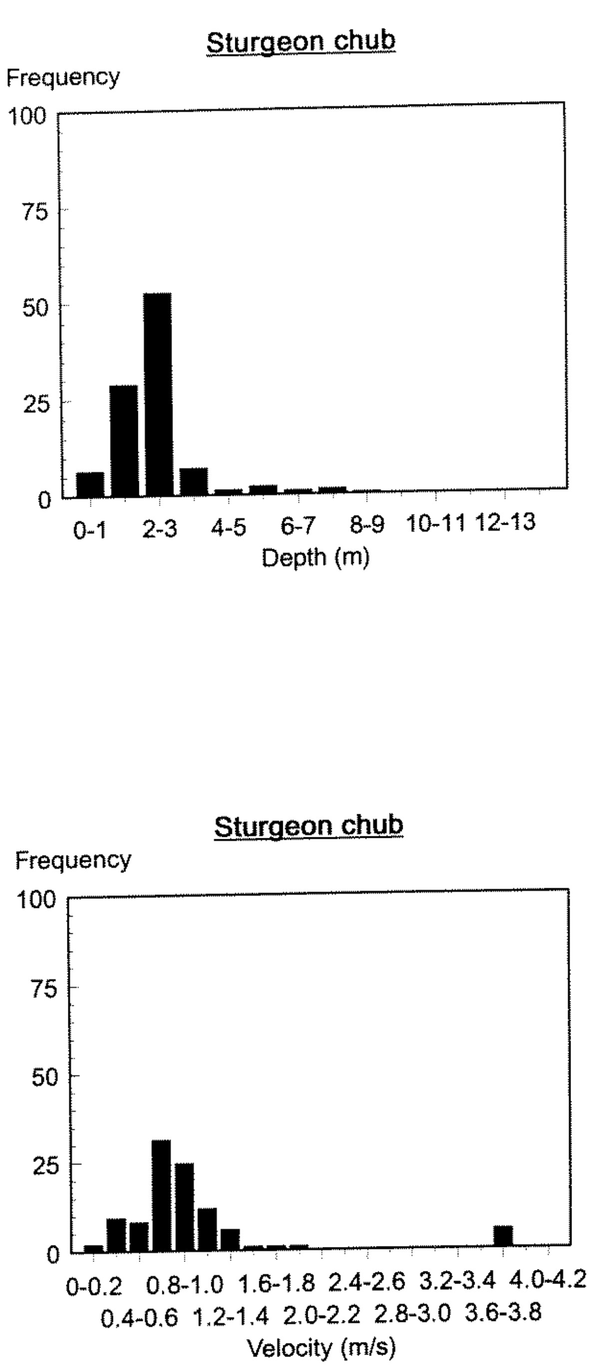


Figure 28. Frequency of occurrence of sturgeon chub (N=308) in various depth, velocity, turbidity, and water temperature intervals from Missouri and Lower Yellowstone River collections in 1996.

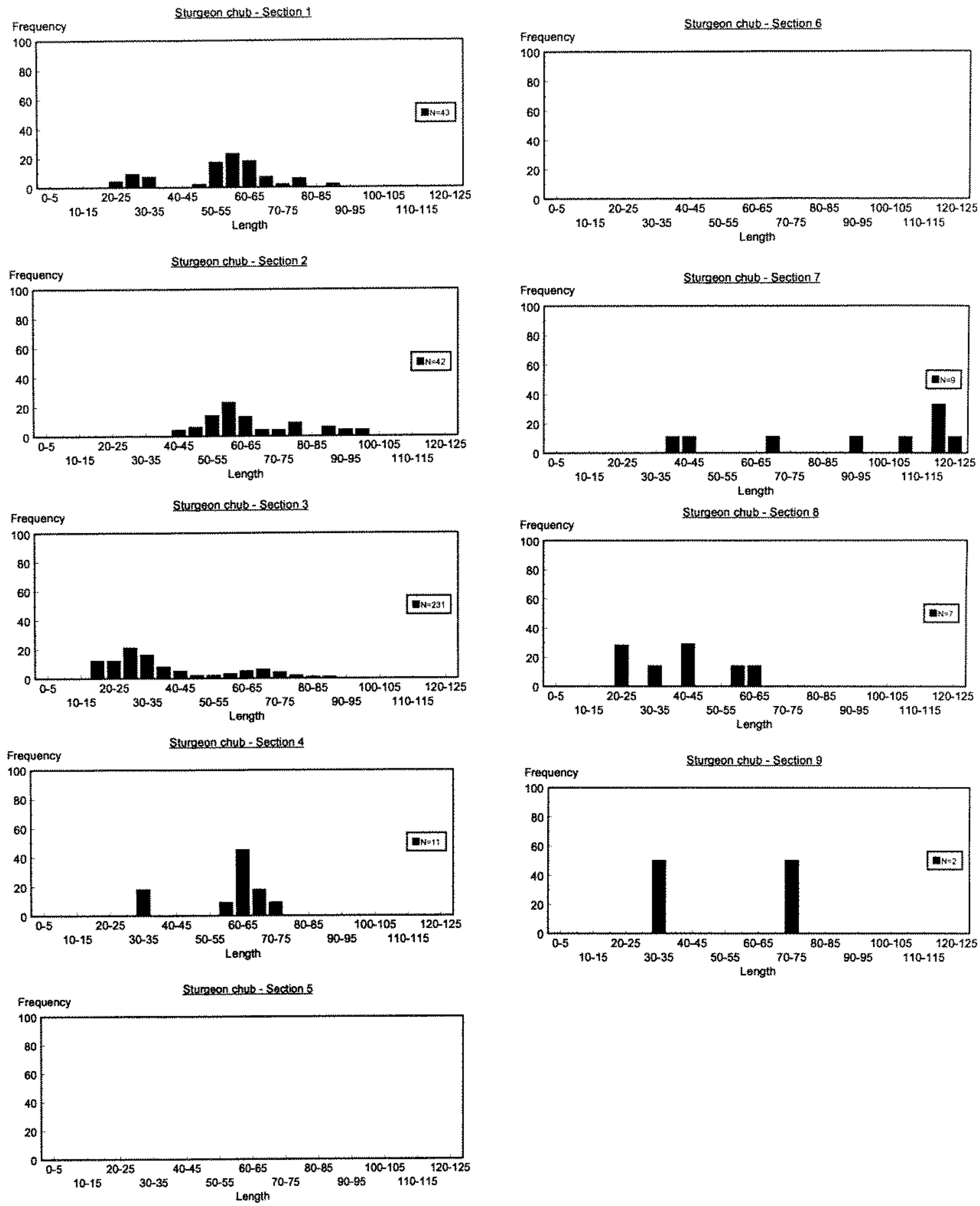


Figure 29. Length-frequency histograms of sturgeon chub collected in Missouri River study sections during 1996 by drifting trammel nets, experimental gill nets, a benthic trawl, bag seine, and boat electrofishing.

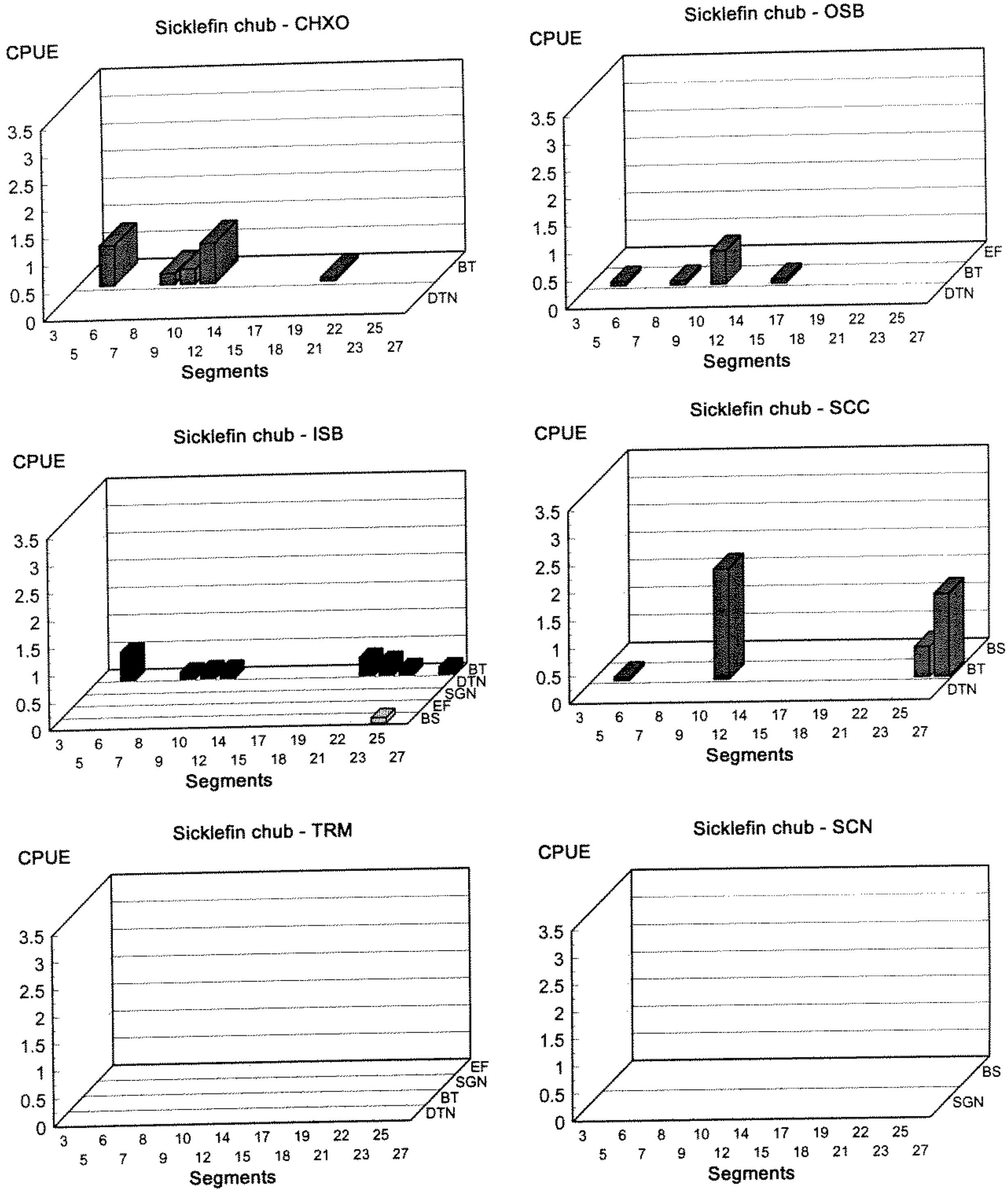


Figure 30. Trends of sicklefin chub catch rates among Missouri River study segments and macrohabitats in 1996. Catch rates for a benthic trawl (BT) and drifting trammel net (DTN) are #/100 m, for a bag seine (BS) - #/180 degree haul, experimental gill net (SGN) - #/hr, and electrofishing (EF) - #/min. See Appendix A for macrohabitat acronyms.

Sicklefin chubs were generally collected in deeper (67% in depths between 1 and 5 m) and faster (83% in velocities > 0.4 m/s) areas than most other species (Figure 31). This is likely due to most being collected with the benthic trawl, which is used in deeper, faster macro- and meso-habitats. Most (about 90%) were collected in turbidities between 10 and 100 NTUs and water temperatures > 18 °C.

Sicklefin chub ranged in size from 25-128 mm total length (Figure 32). In general, larger size classes were apparent in sections **2** (Missouri River below Fort Peck Dam) and 3 (Yellowstone River). However, not all lengths are shown in Figure 32 as some individuals were retained for age and growth analyses and lengths measured in the lab.

Emerald shiner (ERSN)

Emerald shiner were a common species captured in 1996. They were collected in all segments except those downstream of Fort Peck Dam, MT (segments **6, 7,** and **8**) (Figure 33; Tables 23 and 24). The greatest number (2,197) were collected in the unchannelized segment downstream of Gavins Point Dam, SD/NE (segment **15**). They were captured in all macrohabitats except CHXOs. In least-impacted and inter-reservoir segments most were collected in OSBs, SCC, and SCN, while few were collected in TRMs. In channelized segments most were collected in SCC, TRMs, SCN, and ISBs. Boat electrofishing and bag seining were the most effective gears for collecting emerald shiners as drifting trammel net and stationary gill net mesh sizes are obviously too large to permit collection. The benthic trawl however, collected few individuals. Nine percent of emerald shiners were collected in least-impacted segments, 51% in inter-reservoir segments, with most of these again collected in segment **15**, and 40% in channelized segments.

Emerald shiners were generally collected in shallow depths, with none collected in depths > 4 m (Figure 34). Most were collected in slow velocities (< 0.4 m/s), however 30% were collected in the 0.8 to 1.0 m/s velocity interval. They were generally collected in moderate turbidities and warm water temperatures (i.e., about 95% in turbidities from 10-100 NTUs and water temperatures between 20 and 26 °C).

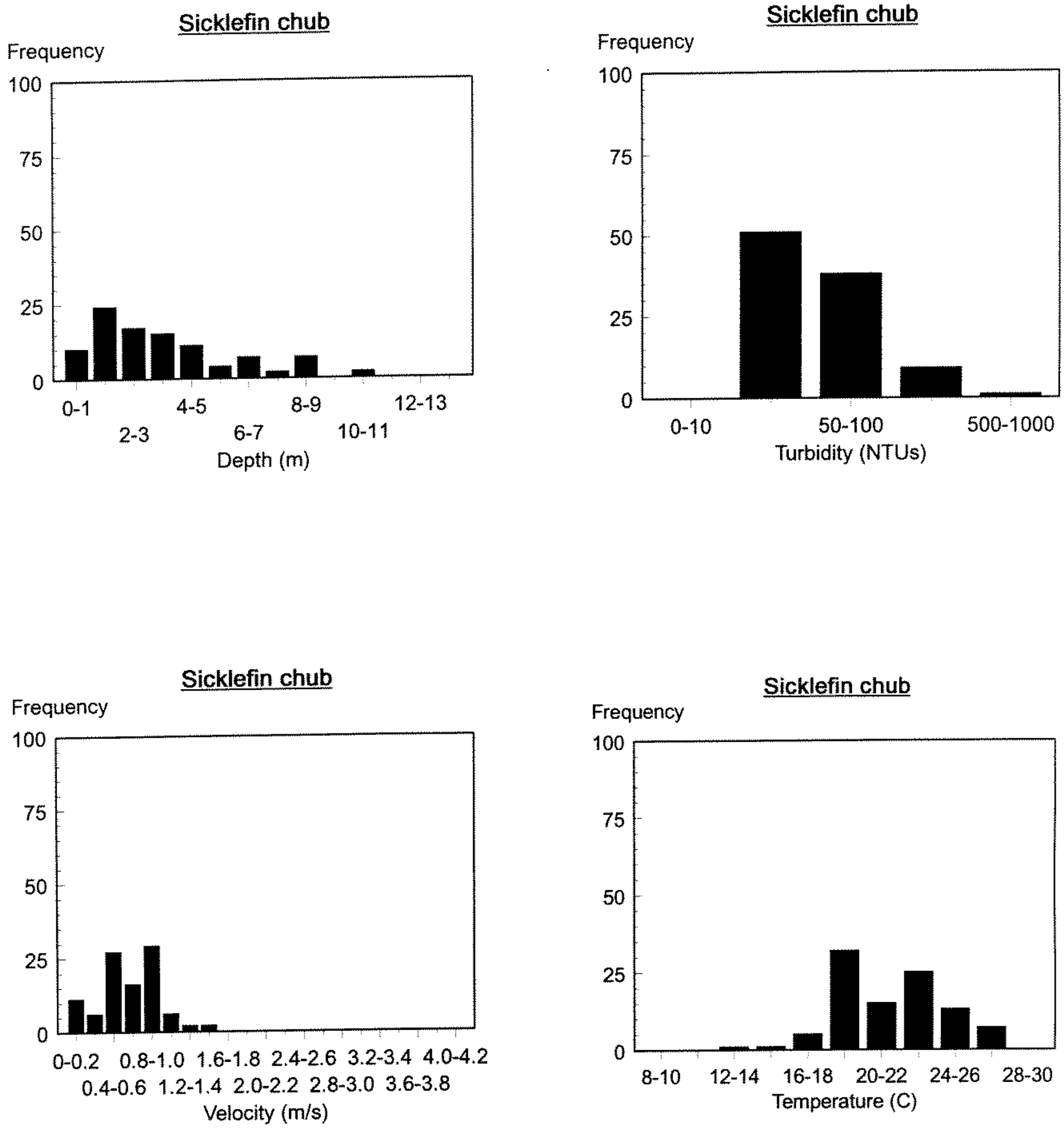


Figure 31. Frequency of occurrence of sicklefin chub (N=83) in various depth, velocity, turbidity, and water temperature intervals from Missouri and Lower Yellowstone River collections in 1996.

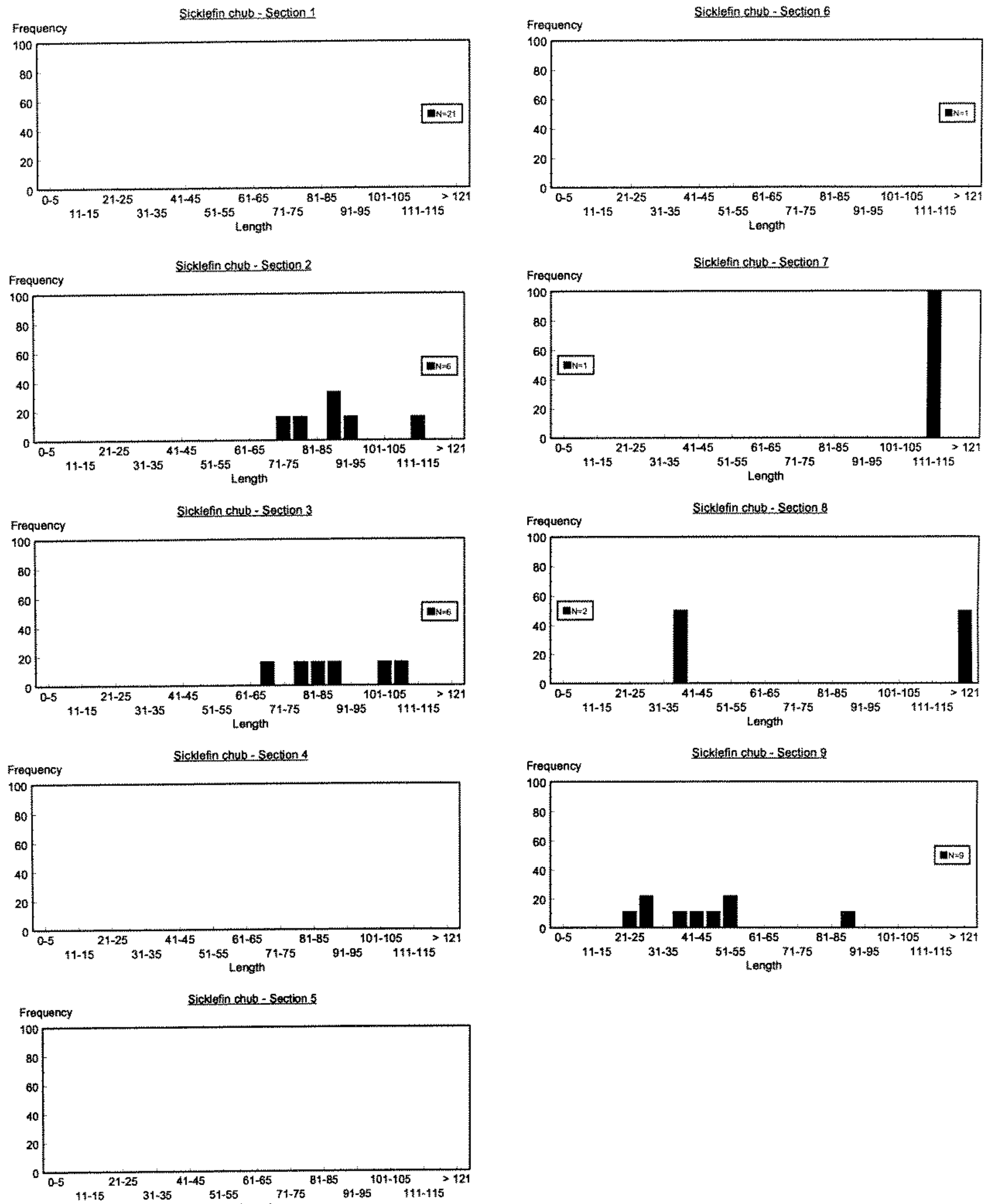


Figure 32. Length-frequency histograms of sicklefin chub collected in Missouri River study sections during 1996 by drifting trammel nets, experimental gill nets, a benthic trawl, bag seine, and boat electrofishing. Some lengths not presented as individuals were sent for age and growth analyses.

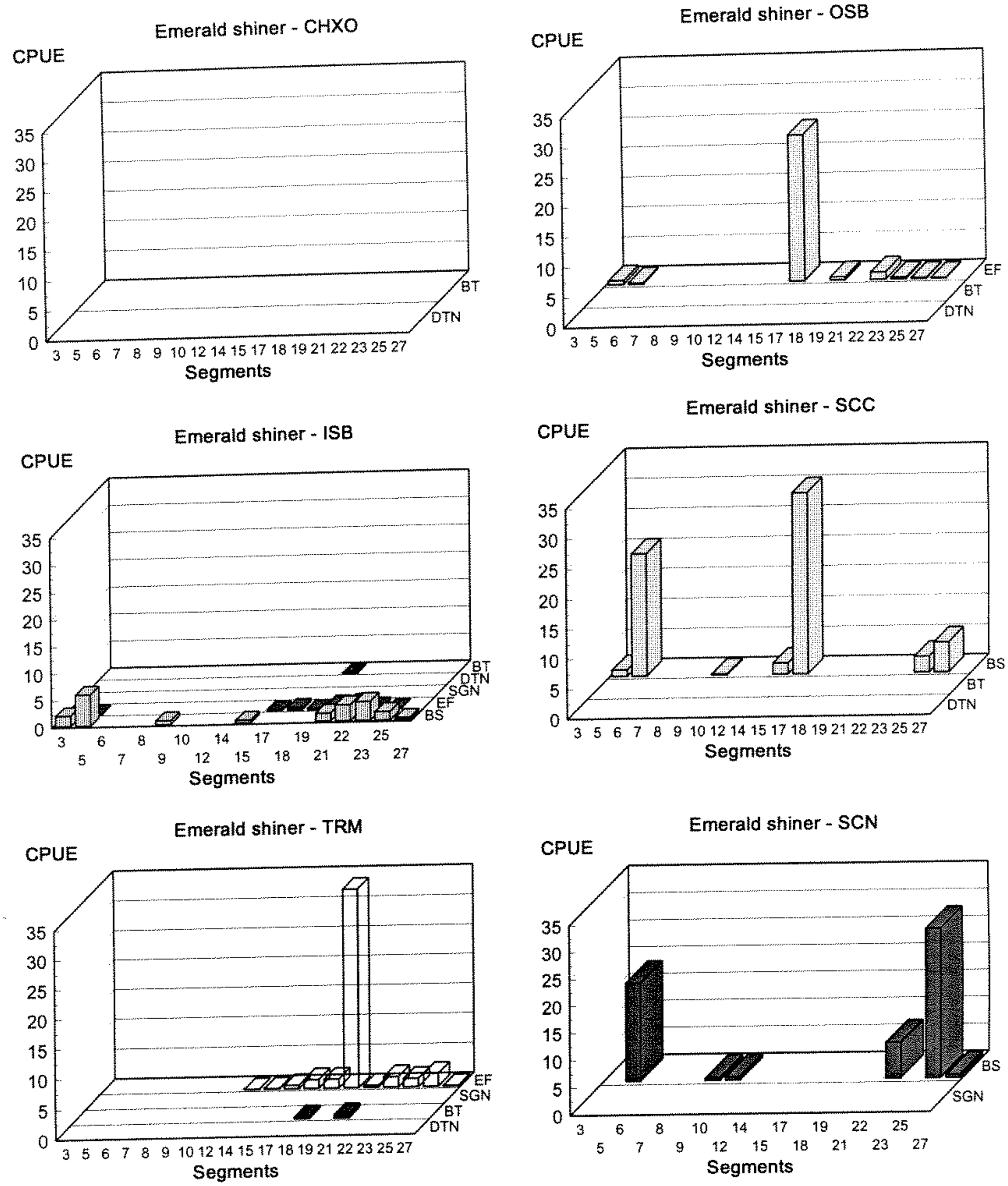


Figure 33. Trends of emerald shiner catch rates among Missouri River study segments and macrohabitats in 1996. Catch rates for a benthic trawl (BT) and drifting trammel net (DTN) are #/100 m, for a bag seine (BS) - #/180 degree haul, experimental gill net (SGN) - #/hr, and electrofishing (EF) - #/min. See Appendix A for macrohabitat acronyms.

Table 23. Relative abundance of emerald shiner collected in 18 Missouri River study segments in continuous macrohabitats (channel crossover-CHXO; outside bend-OSB; and inside bend-ISB) during 1996. Relative abundance in the various gears are #/100 m in drifting trammel nets (DTN) and a benthic trawl (BT); #/hr in stationary gill nets (SGN); #/min with boat electrofishing (EF); and #/180 degree shoreline haul with a bag seine (BS). A "-" indicates not sampled.

	CHXO		OSB			ISB				
Segment	BT	DTN	EF	BT	DTN	BS	SGN	EF	BT	DTN
3	-	0.00	0.64	-	0.00	1.90	-	-	-	0.00
5	0.00	0.00	0.19	0.00	0.00	5.80	-	0.14	0.00	0.00
6	0.00	0.00	-	-	-	0.00	-	-	-	-
7	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
9	0.00	0.00	-	0.00	0.00	0.70	0.00	-	0.00	0.00
10	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	-	-	-	-
14	0.00	0.00	0.02	0.00	0.00	-	-	-	0.00	0.00
15	0.00	0.00	24.29	0.00	0.00	0.50	-	-	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00
18	0.00	0.00	0.52	0.00	0.00	-	0.00	0.45	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	-	0.00	0.20	0.07	0.00
21	0.00	0.00	1.21	0.00	0.00	1.50	0.00	0.94	0.00	0.00
22	0.00	0.00	0.30	0.00	0.00	3.00	0.00	1.20	0.00	0.00
23	0.00	0.00	0.15	0.00	0.00	3.50	0.00	0.43	0.00	0.00
25	0.00	0.00	0.11	0.00	0.00	1.60	0.00	0.04	0.00	0.00
27	0.00	0.00	0.00	0.00	0.00	0.40	0.00	0.00	0.00	0.00

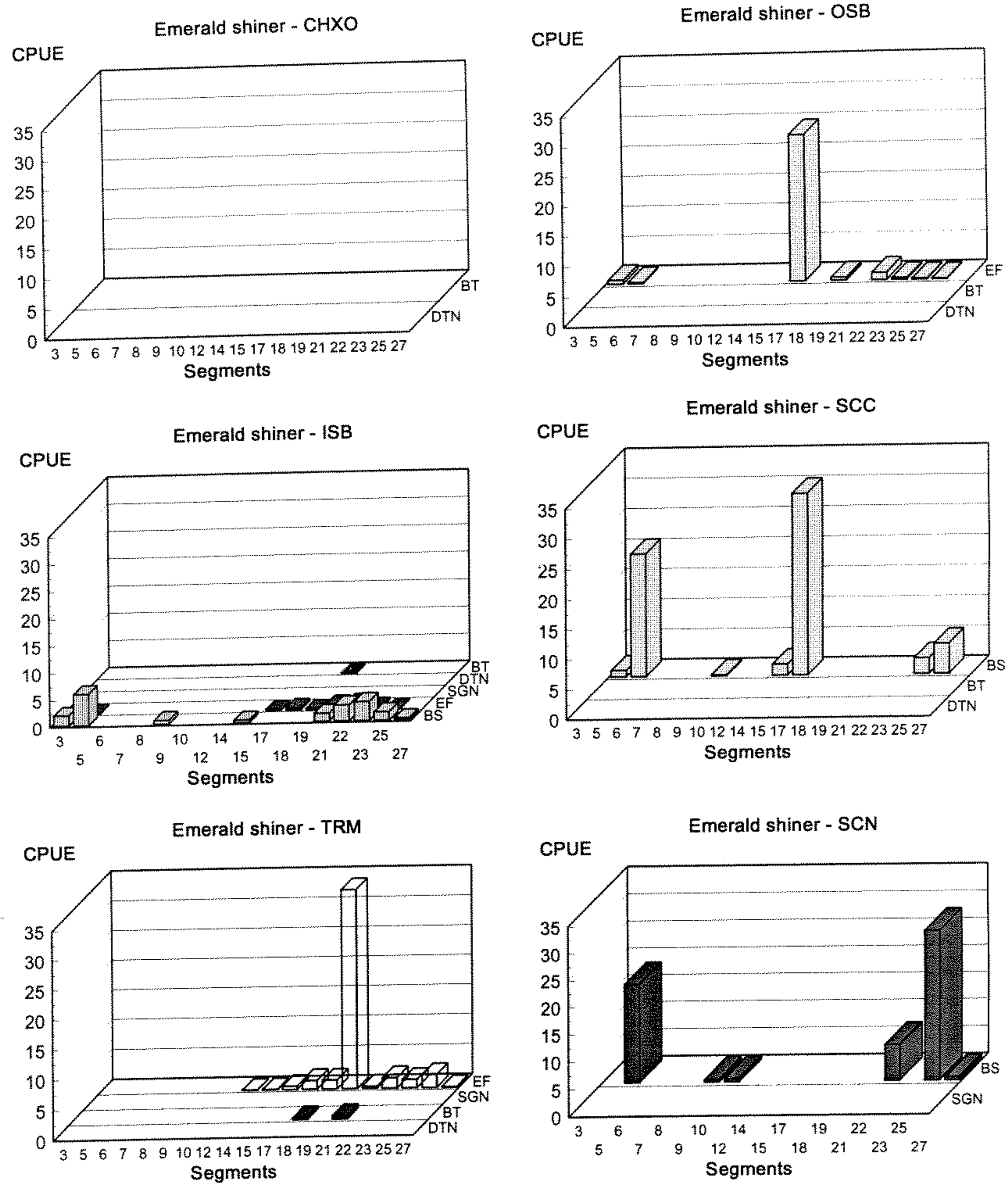


Figure 33. Trends of emerald shiner catch rates among Missouri River study segments and macrohabitats in 1996. Catch rates for a benthic trawl (BT) and drifting trammel net (DTN) are #/100 m, for a bag seine (BS) - #/180 degree haul, experimental gill net (SGN) - #/hr, and electrofishing (EF) - #/min. See Appendix A for macrohabitat acronyms.

Table 23. Relative abundance of emerald shiner collected in 18 Missouri River study segments in continuous macrohabitats (channel crossover-CHXO; outside bend-OSB; and inside bend-ISB) during 1996. Relative abundance in the various gears are #/100 m in drifting trammel nets (DTN) and a benthic trawl (BT); #/hr in stationary gill nets (SGN); #/min with boat electrofishing (EF); and #/180 degree shoreline haul with a bag seine (BS). A "-" indicates not sampled.

	CHXO		OSB			ISB				
Segment	BT	DTN	EF	BT	DTN	BS	SGN	EF	BT	DTN
3	-	0.00	0.64	-	0.00	1.90	-	-	-	0.00
5	0.00	0.00	0.19	0.00	0.00	5.80	-	0.14	0.00	0.00
6	0.00	0.00	-	-	-	0.00	-	-	-	-
7	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
9	0.00	0.00	-	0.00	0.00	0.70	0.00	-	0.00	0.00
10	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	-	-	-	-
14	0.00	0.00	0.02	0.00	0.00	-	-	-	0.00	0.00
15	0.00	0.00	24.29	0.00	0.00	0.50	-	-	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00
18	0.00	0.00	0.52	0.00	0.00	-	0.00	0.45	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	-	0.00	0.20	0.07	0.00
21	0.00	0.00	1.21	0.00	0.00	1.50	0.00	0.94	0.00	0.00
22	0.00	0.00	0.30	0.00	0.00	3.00	0.00	1.20	0.00	0.00
23	0.00	0.00	0.15	0.00	0.00	3.50	0.00	0.43	0.00	0.00
25	0.00	0.00	0.11	0.00	0.00	1.60	0.00	0.04	0.00	0.00
27	0.00	0.00	0.00	0.00	0.00	0.40	0.00	0.00	0.00	0.00

Table 24. Relative abundance of emerald shiner collected in 18 Missouri River study segments in discrete macrohabitats (secondary channels connected-SCC; secondary channels non-connected-SCN; tributary mouths-TRM) during 1996. Relative abundance in the various gears are #/100 m in drifting trammel nets (DTN) and a benthic trawl (BT); #/hr in stationary gill nets (SGN); #/min with boat electrofishing (EF); and #/180 degree shoreline haul with a bag seine (BS). A "-" indicates not sampled.

	SCC			SCN		TRM			
Segment	BT	DTN	BS	SGN	BS	EF	SGN	BT	DTN
3	-	-	1.10	-	-	-	-	-	-
5	0.00	0.00	20.33	0.00	18.00	-	-	-	-
6	-	-	0.00	0.00	0.00	-	0.00	-	-
7	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	-	-
9	0.00	0.00	0.20	0.00	0.40	-	-	-	-
10	0.00	0.00	0.00	0.00	0.50	-	-	-	-
12	0.00	0.00	0.00	0.00	0.00	0.03	0.00	-	-
14	0.00	0.00	1.88	0.00	0.00	0.07	0.00	-	-
15	0.00	0.00	30.00	0.00	0.00	0.55	0.00	-	-
17	-	-	-	-	-	1.48	0.00	-	0.00
18	0.00	0.00	-	-	-	1.50	0.00	0.33	0.00
19	0.00	-	0.00	-	-	33.39	0.00	-	0.00
21	0.00	0.00	-	-	-	0.37	0.00	0.60	0.00
22	-	-	0.00	0.00	6.50	1.73	0.00	0.00	0.00
23	0.00	0.00	2.67	0.00	0.00	1.40	0.00	0.00	0.00
25	0.00	0.00	5.00	0.00	27.50	2.16	0.00	0.00	0.00
27	0.00	0.00	0.00	0.00	0.50	0.09	0.00	-	-

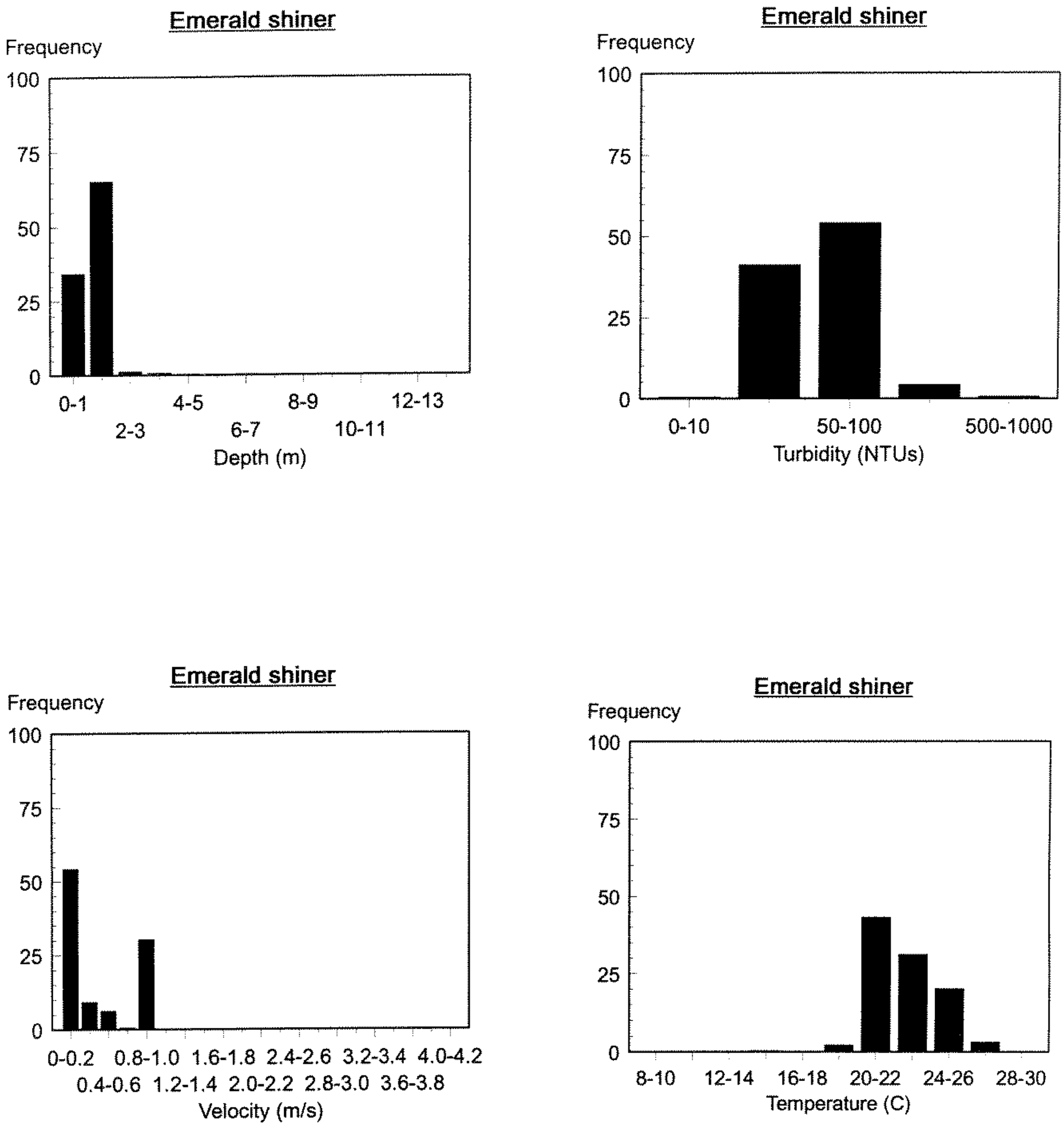


Figure 34. Frequency of occurrence of emerald shiner (N=4,395) in various depth, velocity, turbidity, and water temperature intervals from Missouri and Lower Yellowstone River collections in 1996.

Emerald shiners ranged in length from 19-101 mm total length (Figure 35). In channelized sections most were < 50 mm, while in least impacted sections (1 and 3) most were > 50 mm. Inter-reservoir section lengths are not presented because many individuals were sent for age and growth analyses and data had not been compiled by the time of this report.

Sand shiner (SNSN)

Sand shiner were generally scarce in all segments except **15**, the unchannelized segment downstream of Gavins Point Dam, SD/NE, where most individuals were collected in SCC-SHLW mesohabitats. Over all segments, 153 sand shiners were captured in 1996 with 75% of these from segment **15**. No sand shiners were collected in least-impacted segments, while 21% were captured in channelized segments. They were collected in all macrohabitats except CHXOs (Figure 36; Tables 25 and 26). In channelized segments most were captured in ISB-BARS.

Sand shiner generally used shallow depths (96% in depths < 1 m) and slow velocities (90% in velocities < 0.4 m/s) (Figure 37). Most were captured in moderately clear (79% in 10-50 NTUs interval), warm waters (70% in water temperatures between 24 and 26 °C). Almost all sand shiners were sent for age and growth analyses so no size structure information is presented here.

Hybognathus spp. (HBNS)

One-thousand-seven-hundred-fifty-nine individuals of *Hybognathus* spp. were collected during 1996 in bag seines, benthic trawls, and by electrofishing. They were collected in all macrohabitats except CHXOs (Figure 38; Tables 27 and 28). Most were collected in least-impacted (49%) and channelized (47%) segments. In inter-reservoir segments they were uncommon except in segment **15** (unchannelized segment downstream of Gavins Point Dam, SD/NE) where 70 were collected. Most were collected in ISB-BARS, SCC-SHLW, and SCN macro- and meso-habitats in channelized and least-impacted segments.

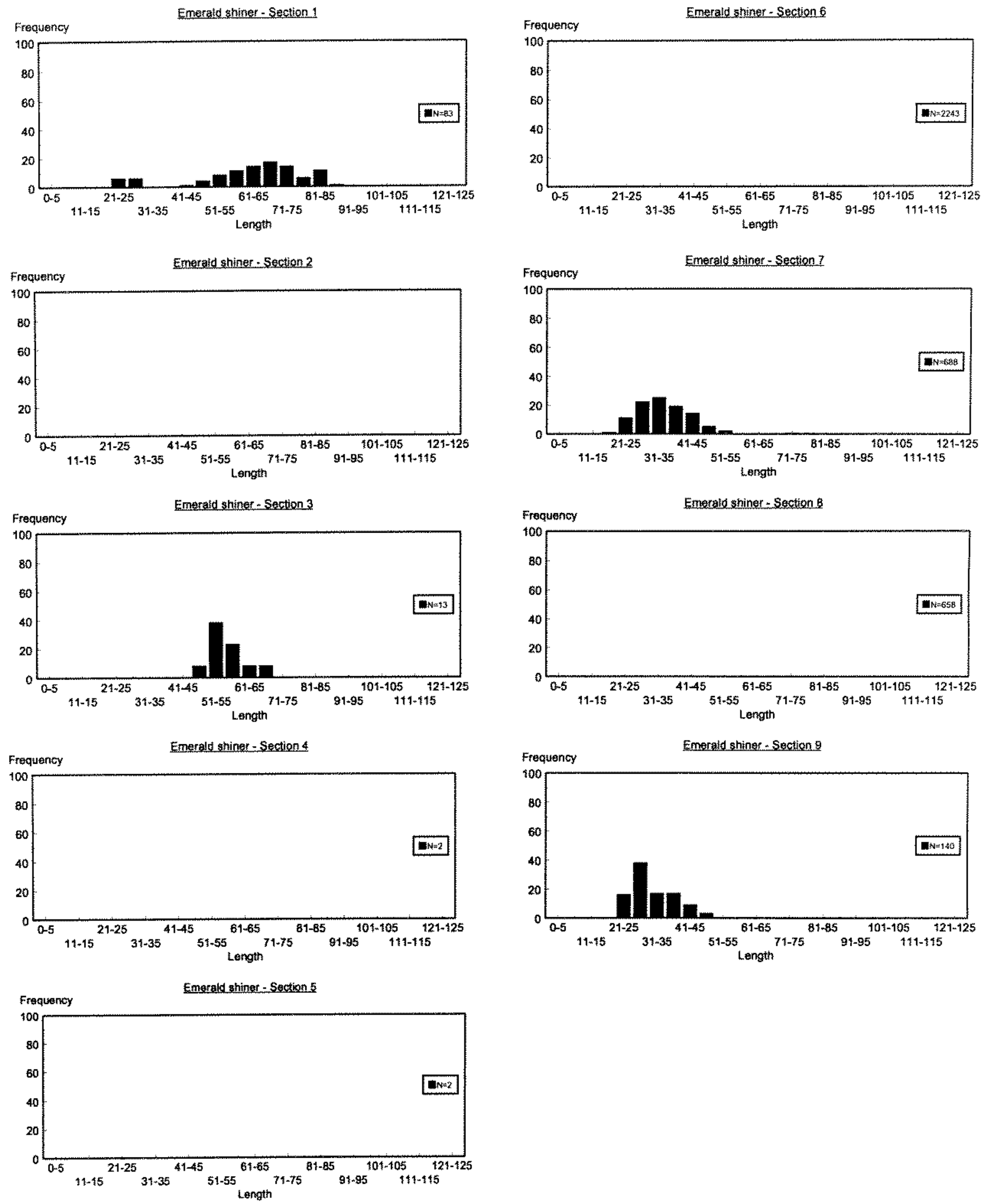


Figure 35. Length-frequency histograms of emerald shiner collected in Missouri River study sections during 1996 by drifting trammel nets, experimental gill nets, a benthic trawl, bag seine, and boat electrofishing. Some lengths not presented as individuals were sent for age and growth analyses.

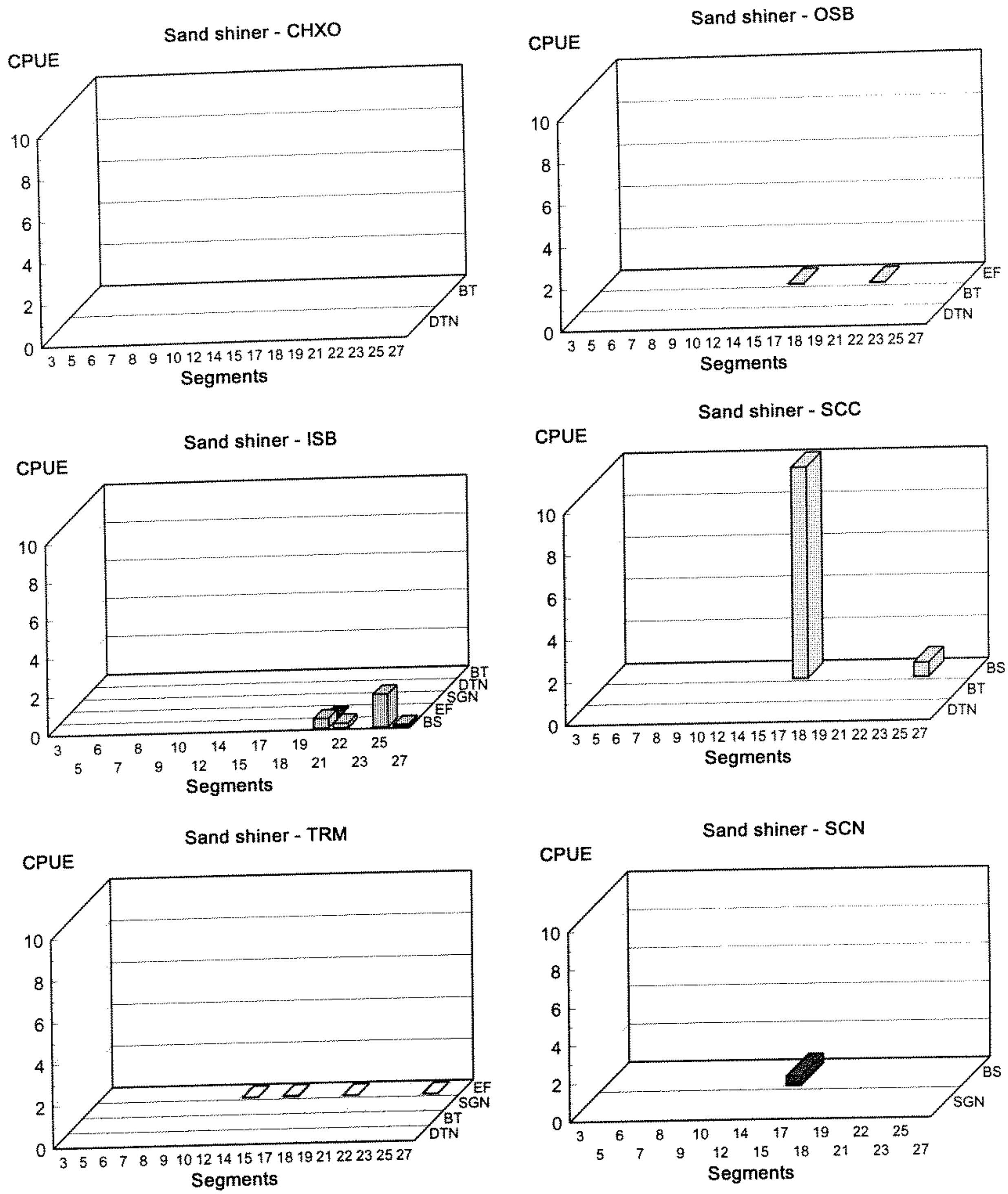


Figure 36. Trends of sand shiner catch rates among Missouri River study segments and macrohabitats in 1996. Catch rates for a benthic trawl (BT) and drifting trammel net (DTN) are #/100 m, for a bag seine (BS) - #/180 degree haul, experimental gill net (SGN) - #/hr, and electrofishing (EF) - #/min. See Appendix A for macrohabitat acronyms.

Table 25. Relative abundance of sand shiner collected in 18 Missouri River study segments in continuous macrohabitats (channel crossover-CHXO; outside bend-OSB; and inside bend-ISB) during 1996. Relative abundance in the various gears are #/100 m in drifting trammel nets (DTN) and a benthic trawl (BT); #/hr in stationary gill nets (SGN); #/min with boat electrofishing (EF); and #/180 degree shoreline haul with a bag seine (BS). A "-" indicates not sampled.

	CHXO		OSB			ISB				
Segment	BT	DTN	EF	BT	DTN	BS	SGN	EF	BT	DTN
3	-	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
6	0.00	0.00	-	-	-	0.00	-	-	-	-
7	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
9	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
12	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
15	0.00	0.00	0.01	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
18	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
21	0.00	0.00	0.01	0.00	0.00	0.50	0.00	0.01	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.25	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
25	0.00	0.00	0.00	0.00	0.00	1.70	0.00	0.00	0.00	0.00
27	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00

Table 26. Relative abundance of sand shiner collected in 18 Missouri River study segments in discrete macrohabitats (secondary channels connected-SCC; secondary channels non-connected-SCN; tributary mouths-TRM) during 1996. Relative abundance in the various gears are #/100 m in drifting trammel nets (DTN) and a benthic trawl (BT); #/hr in stationary gill nets (SGN); #/min with boat electrofishing (EF); and #/180 degree shoreline haul with a bag seine (BS). A "-" indicates not sampled.

	SCC			SCN		TRM			
Segment	BT	DTN	BS	SGN	BS	EF	SGN	BT	DTN
3	-	-	0.00	-	-	-	-	-	-
5	0.00	0.00	0.00	0.00	0.00	-	-	-	-
6	-	-	0.00	0.00	0.00	-	0.00	-	-
7	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	-	-
9	0.00	0.00	0.00	0.00	0.00	-	-	-	-
10	0.00	0.00	0.00	0.00	0.00	-	-	-	-
12	0.00	0.00	0.00	0.00	0.00	0.02	0.00	-	-
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-
15	0.00	0.00	0.00	0.00	0.50	0.05	0.00	-	-
17	-	-	-	-	-	0.00	0.00	-	0.00
18	0.00	0.00	-	-	-	0.00	0.00	0.00	0.00
19	0.00	-	0.00	-	-	0.01	0.00	-	0.00
21	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
23	0.00	0.00	0.67	0.00	0.00	0.00	0.00	0.00	0.00
25	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-

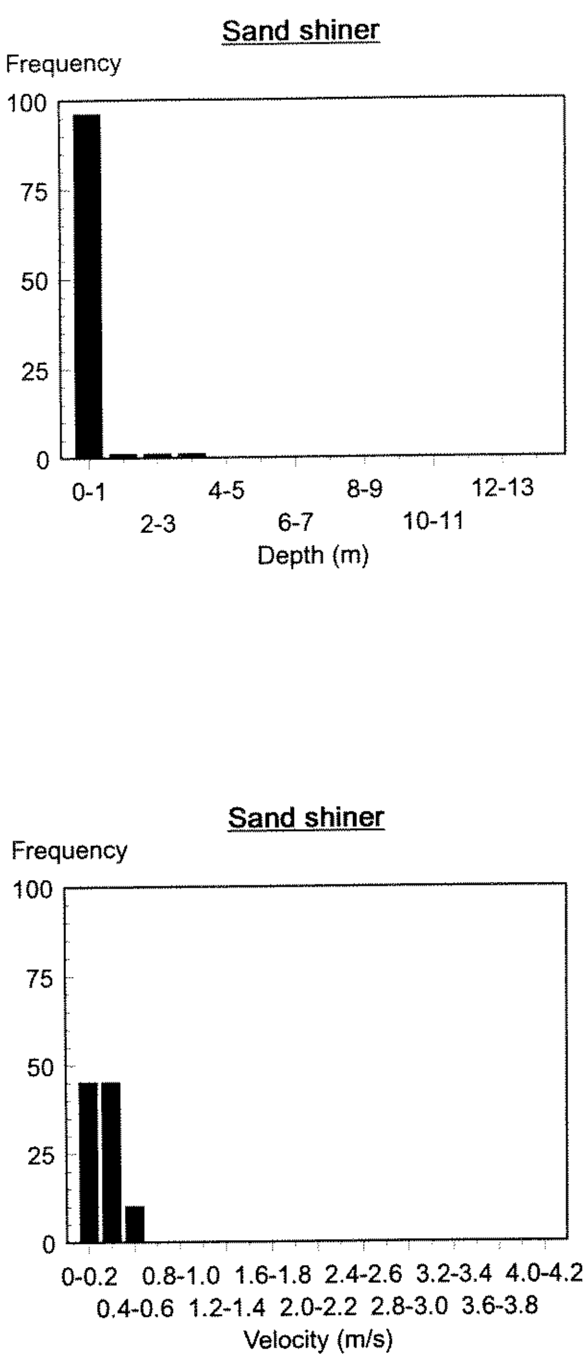


Figure 37. Frequency of occurrence of sand shiner (N=149) in various depth, velocity, turbidity, and water temperature intervals from Missouri and Lower Yellowstone River collections in 1996.

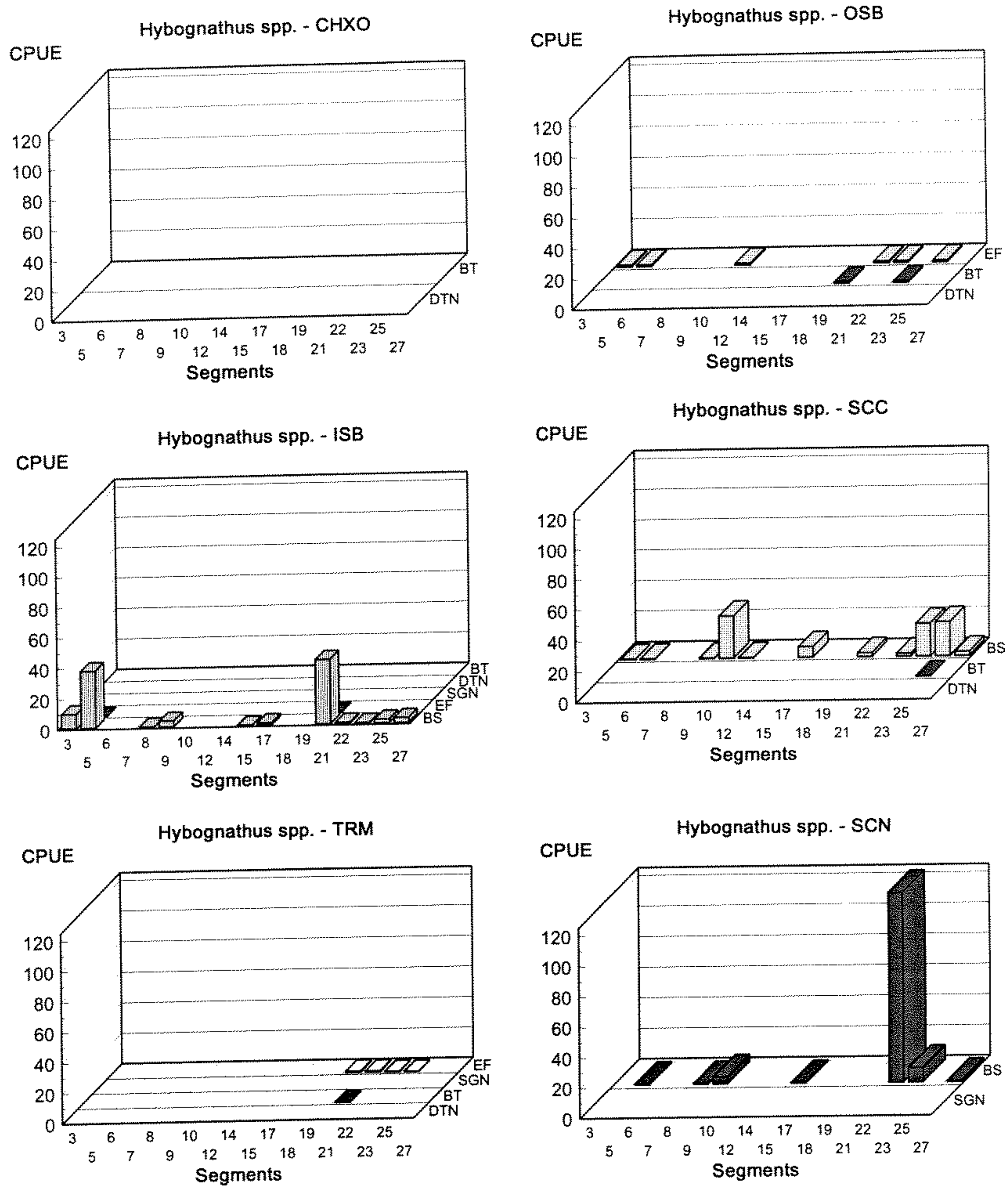


Figure 38. Trends of *Hybognathus* spp. catch rates among Missouri River study segments and macrohabitats in 1996. Catch rates for a benthic trawl (BT) and drifting trammel net (DTN) are #/100 m, for a bag seine (BS) - #/180 degree haul, experimental gill net (SGN) - #/hr, and electrofishing (EF) - #/min. See Appendix A for macrohabitat acronyms.

Table 27. Relative abundance of *Hybognathus* spp. collected in 18 Missouri River study segments in continuous macrohabitats (channel crossover-CHXO; outside bend-OSB; and inside bend-ISB) during 1996. Relative abundance in the various gears are #/100 m in drifting trammel nets (DTN) and a benthic trawl (BT); #/hr in stationary gill nets (SGN); #/min with boat electrofishing (EF); and #/180 degree shoreline haul with a bag seine (BS). A "-" indicates not sampled.

	CHXO		OSB			ISB				
Segment	BT	DTN	EF	BT	DTN	BS	SGN	EF	BT	DTN
3	-	0.00	0.07	-	0.00	9.50	-	-	-	0.00
5	0.00	0.00	0.05	0.00	0.00	37.40	-	0.10	0.00	0.00
6	0.00	0.00	-	-	-	0.00	-	-	-	-
7	0.00	0.00	-	0.00	0.00	0.00	-	-	0.00	0.00
8	0.00	0.00	-	0.00	0.00	0.10	0.00	-	0.00	0.00
9	0.00	0.00	-	0.00	0.00	3.90	0.00	-	0.00	0.00
10	0.00	0.00	0.01	0.00	0.00	0.00	-	-	0.00	0.00
12	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
15	0.00	0.00	0.00	0.00	0.00	0.17	-	-	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	1.50	0.00	0.00	0.00	0.00
18	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	0.07	0.00	-	0.00	0.05	0.00	0.00
21	0.00	0.00	0.29	0.00	0.00	42.00	0.00	0.33	0.00	0.00
22	0.00	0.00	0.01	0.00	0.00	0.75	0.00	0.06	0.00	0.00
23	0.00	0.00	0.00	0.07	0.00	0.50	0.00	0.01	0.00	0.00
25	0.00	0.00	0.01	0.00	0.00	2.40	0.00	0.00	0.00	0.00
27	0.00	0.00	0.00	0.00	0.00	3.30	0.00	0.00	0.00	0.00

Table 28. Relative abundance of *Hybognathus* spp. collected in 18 Missouri River study segments in discrete macrohabitats (secondary channels connected-SCC; secondary channels non-connected-SCN; tributary mouths-TRM) during 1996. Relative abundance in the various gears are #/100 m in drifting trammel nets (DTN) and a benthic trawl (BT); #/hr in stationary gill nets (SGN); #/min with boat electrofishing (EF); and #/180 degree shoreline haul with a bag seine (BS). A "-" indicates not sampled.

	SCC			SCN		TRM			
Segment	BT	DTN	BS	SGN	BS	EF	SGN	BT	DTN
3	-	-	0.20	-	-	-	-	-	-
5	0.06	0.00	0.33	0.00	0.50	-	-	-	-
6	-	-	0.00	0.00	0.00	-	0.00	-	-
7	0.00	0.00	0.00	0.00	0.00	-	0.00	-	-
8	0.00	0.00	0.33	0.00	0.30	-	0.00	-	-
9	0.00	0.00	27.40	0.00	4.70	-	-	-	-
10	0.00	0.00	0.25	0.00	0.00	-	-	-	-
12	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	-	-
15	0.00	0.00	6.80	0.00	0.25	0.00	0.00	-	-
17	-	-	-	-	-	0.00	0.00	-	0.00
18	0.00	0.00	-	-	-	0.00	0.00	0.00	0.00
19	0.00	-	2.50	-	-	0.92	0.00	-	0.00
21	0.00	0.00	-	-	-	0.91	0.00	0.17	0.00
22	-	-	2.00	0.00	124.0	0.36	0.00	0.00	0.00
23	0.00	0.00	21.33	0.00	9.50	0.10	0.00	0.00	0.00
25	0.17	0.00	22.00	0.00	0.00	0.02	0.00	0.00	0.00
27	0.00	0.00	2.75	0.00	0.63	0.00	0.00	-	-

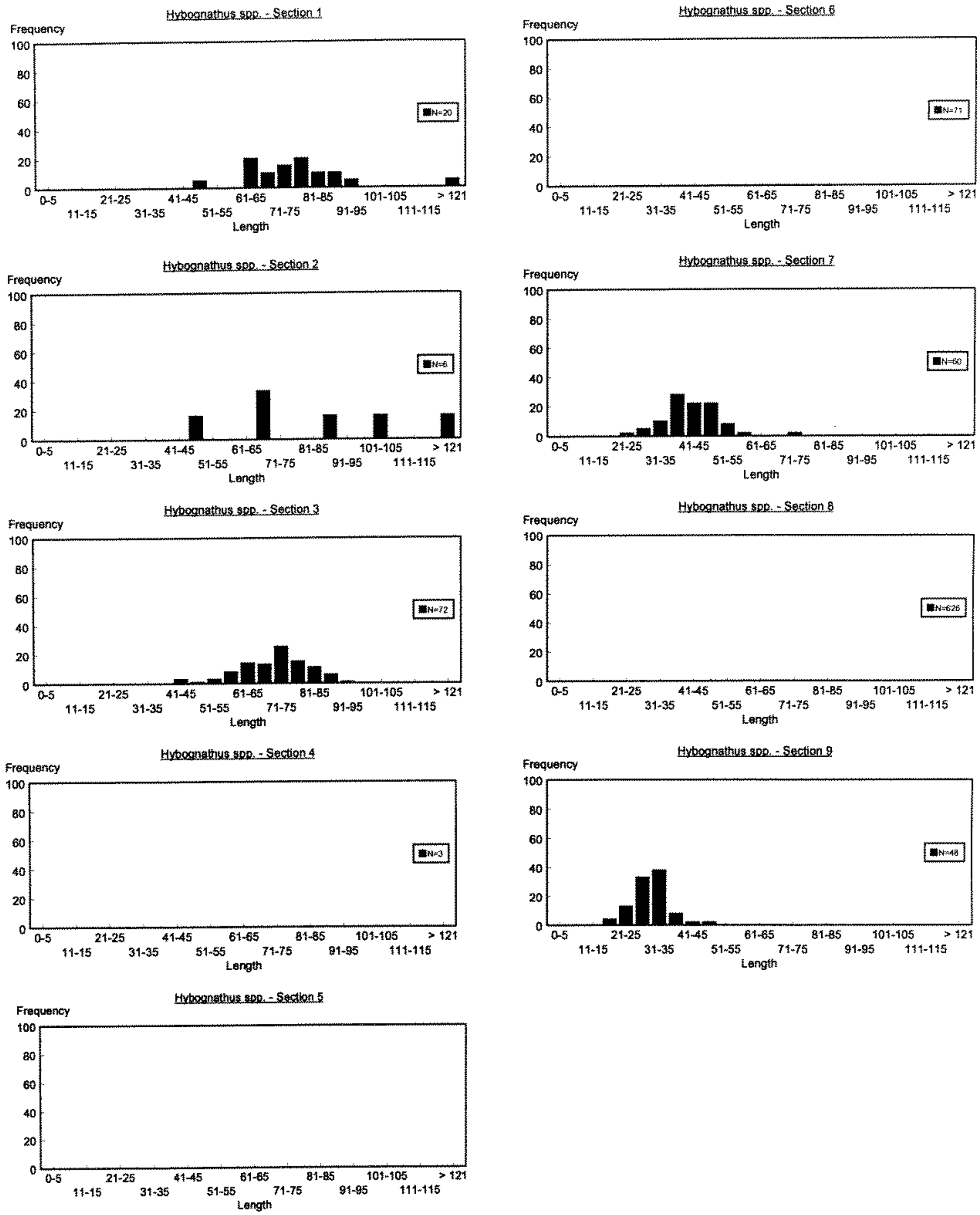


Figure 40. Length-frequency histograms of *Hybognathus* spp. collected in Missouri River study sections during 1996 by drifting trammel nets, experimental gill nets, a benthic trawl, bag seine, and boat electrofishing. Some lengths not presented as individuals were sent for age and growth analyses.

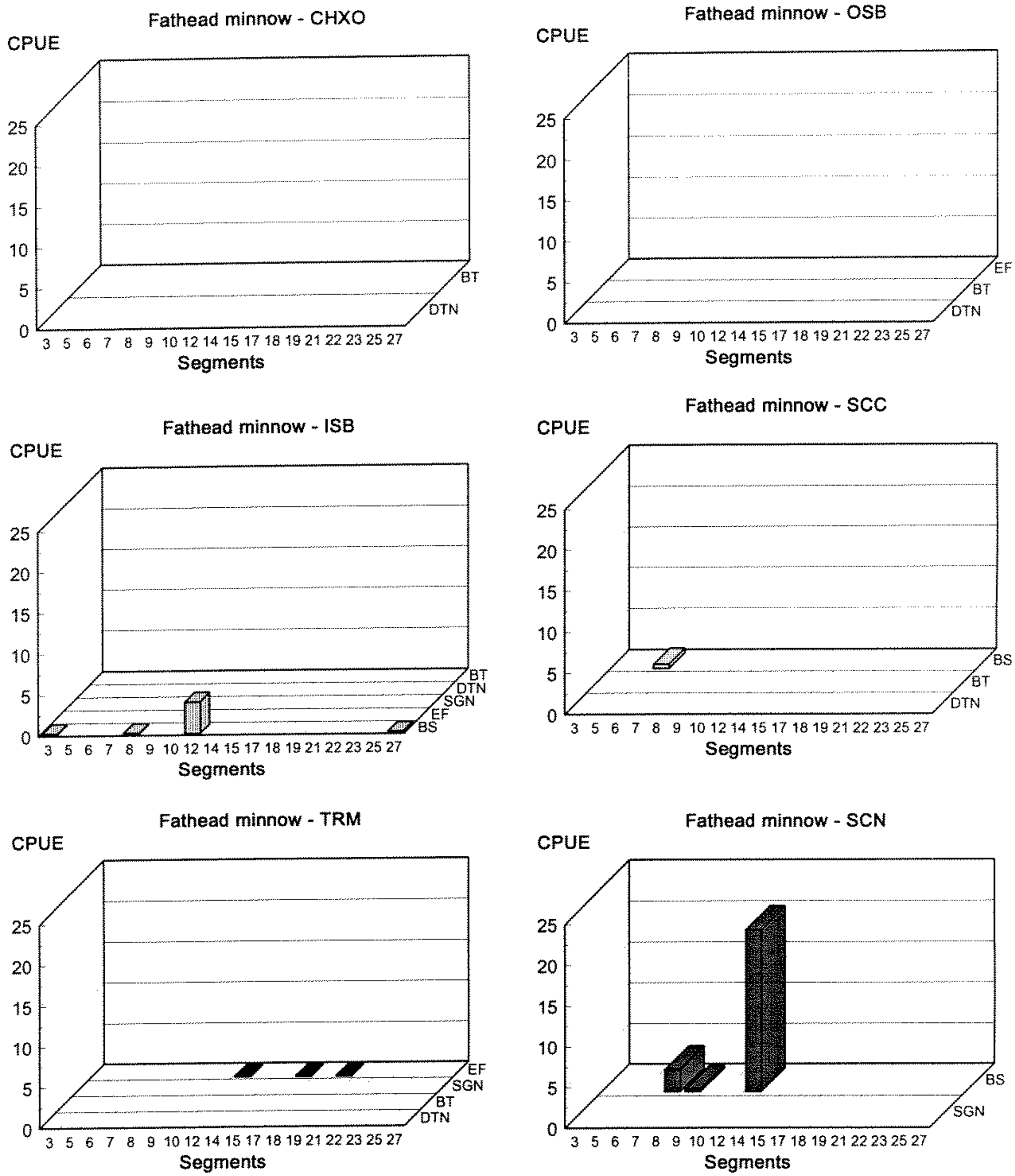


Figure 41. Trends in fathead minnow catch rates among Missouri River study segments and macrohabitats in 1996. Catch rates for a benthic trawl (BT) and drifting trammel net (DTN) are #/100 m, for a bag seine (BS) - #/180 degree haul, experimental gill net (SGN) - #/hr, and electrofishing (EF) - #/min. See Appendix A for macrohabitat acronyms.

Table 29. Relative abundance of fathead minnow collected in 18 Missouri River study segments in continuous macrohabitats (channel crossover-CHXO; outside bend-OSB; and inside bend-ISB) during 1996. Relative abundance in the various gears are #/100 m in drifting trammel nets (DTN) and a benthic trawl (BT); #/hr in stationary gill nets (SGN); #/min with boat electrofishing (EF); and #/180 degree shoreline haul with a bag seine (BS). A "-" indicates not sampled.

	CHXO		OSB			ISB				
Segment	BT	DTN	EF	BT	DTN	BS	SGN	EF	BT	DTN
3	-	0.00	0.00	-	0.00	0.10	-	-	-	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	-	0.00	0.00	0.00
6	0.00	0.00	-	-	-	0.00	-	-	-	-
7	0.00	0.00	-	0.00	0.00	0.00	-	-	0.00	0.00
8	0.00	0.00	-	0.00	0.00	0.10	0.00	-	0.00	0.00
9	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
12	0.00	0.00	0.00	0.00	0.00	3.88	-	-	-	-
14	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
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	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
21	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
23	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
27	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00

Table 30. Relative abundance of fathead minnow collected in 18 Missouri River study segments in discrete macrohabitats (secondary channels connected-SCC; secondary channels non-connected-SCN; tributary mouths-TRM) during 1996. Relative abundance in the various gears are #/100 m in drifting trammel nets (DTN) and a benthic trawl (BT); #/hr in stationary gill nets (SGN); #/min with boat electrofishing (EF); and #/180 degree shoreline haul with a bag seine (BS). A "-" indicates not sampled.

	SCC			SCN		TRM			
Segment	BT	DTN	BS	SGN	BS	EF	SGN	BT	DTN
3	-	-	0	-	-	-	-	-	-
5	0.00	0.00	0.00	0.00	0.00	-	-	-	-
6	-	-	0.50	0.00	0.00	-	0.00	-	-
7	0.00	0.00	0.00	0.00	2.75	-	0.00	-	-
8	0.00	0.00	0.00	0.00	0.30	-	0.00	-	-
9	0.00	0.00	0.00	0.00	0.00	-	-	-	-
10	0.00	0.00	0.00	0.00	0.00	-	-	-	-
12	0.00	0.00	0.00	0.00	19.90	0.02	0.00	-	-
14	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	-	-
17	-	-	-	-	-	0.01	0.00	-	0.00
18	0.00	0.00	-	-	-	0.00	0.00	0.00	0.00
19	0.00	-	0.00	-	-	0.01	0.00	-	0.00
21	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
23	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
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-

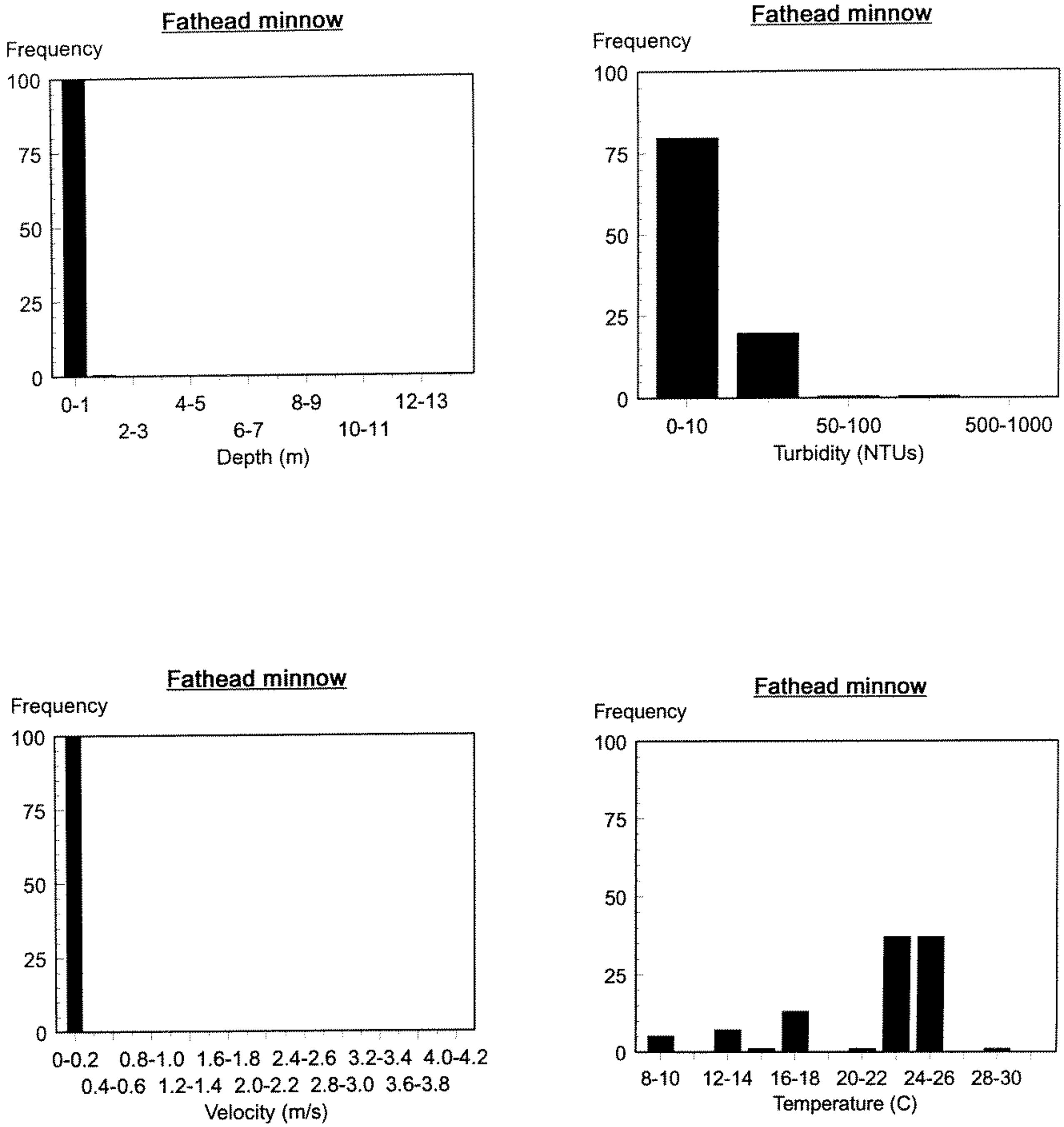


Figure 42. Frequency of occurrence of fathead minnow (N=241) in various depth, velocity, turbidity, and water temperature intervals from Missouri and Lower Yellowstone River collections in 1996.

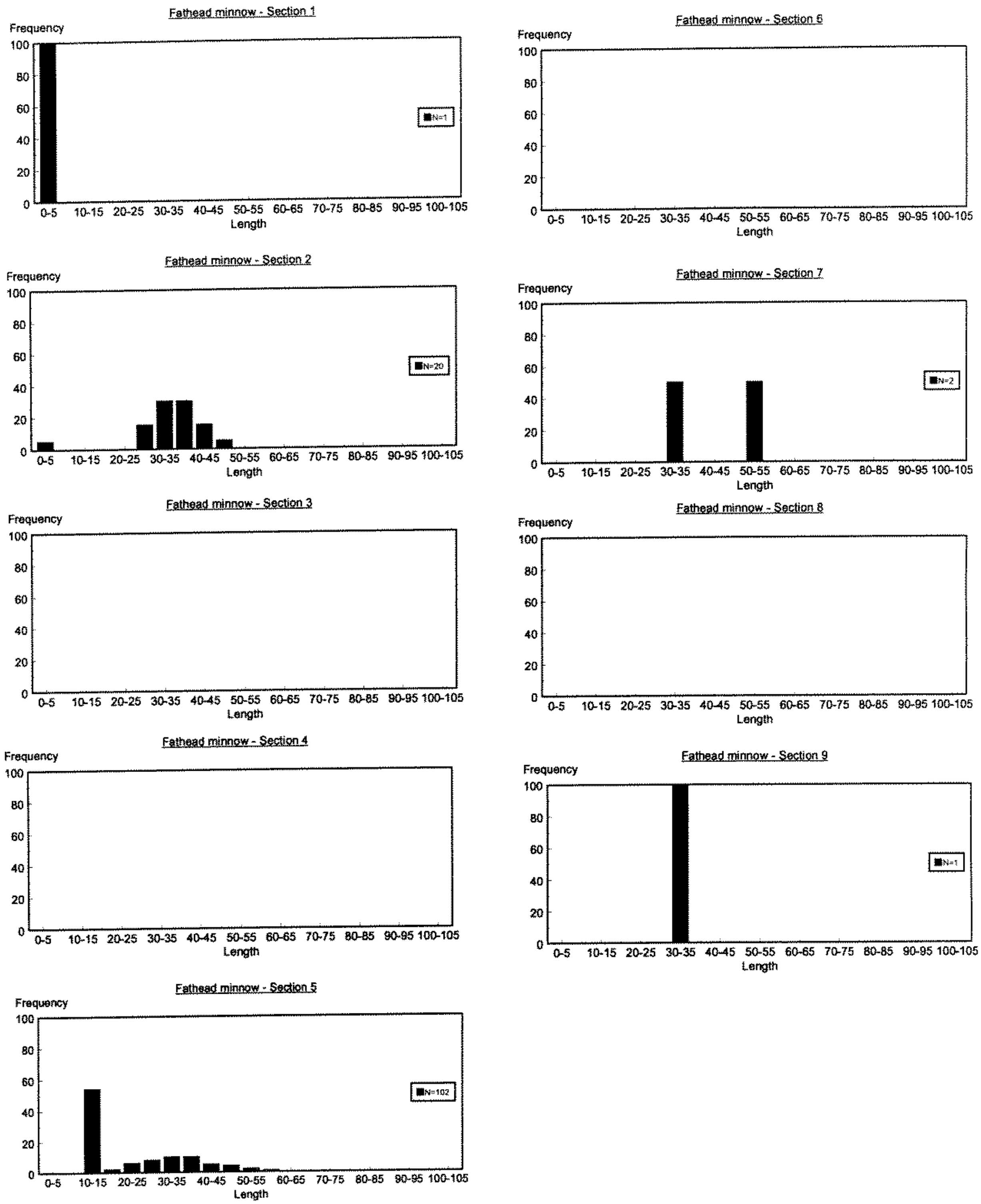


Figure 43. Length-frequency histograms of fathead minnow collected in Missouri River study sections during 1996 by drifting trammel nets, experimental gill nets, a benthic trawl, bag seine, and boat electrofishing.

Table 31. Relative abundance of blue sucker collected in 18 Missouri River study segments in continuous macrohabitats (channel crossover-CHXO; outside bend-OSB; and inside bend-ISB) during 1996. Relative abundance in the various gears are #/100 m in drifting trammel nets (DTN) and a benthic trawl (BT); #/hr in stationary gill nets (SGN); #/min with boat electrofishing (EF); and #/180 degree shoreline haul with a bag seine (BS). A "-" indicates not sampled.

	CHXO		OSB			ISB				
Segment	BT	DTN	EF	BT	DTN	BS	SGN	EF	BT	DTN
3	-	0.00	0.01	-	0.10	0.00	-	-	-	0.00
5	0.00	0.00	0.03	0.00	0.00	0.00	-	0.00	0.00	0.00
6	0.00	0.00	-	-	-	0.00	-	-	-	-
7	0.00	0.00	-	0.00	0.00	0.00	-	-	0.00	0.00
8	0.00	0.07	-	0.00	0.00	0.00	0.00	-	0.00	0.00
9	0.00	0.13	-	0.00	0.00	0.00	0.00	-	0.00	0.00
10	0.00	0.00	0.00	0.07	0.00	0.00	-	-	0.00	0.00
12	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
15	0.00	0.00	0.00	0.00	0.07	0.00	-	-	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.00
18	0.00	0.00	0.03	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
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.22
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	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
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 32. Relative abundance of blue sucker collected in 18 Missouri River study segments in discrete macrohabitats (secondary channels connected-SCC; secondary channels non-connected-SCN; tributary mouths-TRM) during 1996. Relative abundance in the various gears are #/100 m in drifting trammel nets (DTN) and a benthic trawl (BT); #/hr in stationary gill nets (SGN); #/min with boat electrofishing (EF); and #/180 degree shoreline haul with a bag seine (BS). A "-" indicates not sampled.

	SCC			SCN		TRM			
Segment	BT	DTN	BS	SGN	BS	EF	SGN	BT	DTN
3	-	-	0.00	-	-	-	-	-	-
5	0.00	0.00	0.00	0.00	0.00	-	-	-	-
6	-	-	0.00	0.00	0.00	-	0.17	-	-
7	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	-	-
9	0.00	0.00	0.00	0.00	0.00	-	-	-	-
10	0.00	0.00	0.00	0.00	0.00	-	-	-	-
12	0.00	0.00	0.00	0.00	0.00	0.00	0.25	-	-
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-
15	0.00	0.32	0.00	0.00	0.00	0.00	0.00	-	-
17	-	-	-	-	-	0.00	0.00	-	0.00
18	0.00	0.00	-	-	-	0.00	0.00	0.00	0.00
19	0.00	-	0.00	-	-	0.00	0.00	-	0.00
21	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
23	0.00	0.07	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
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-

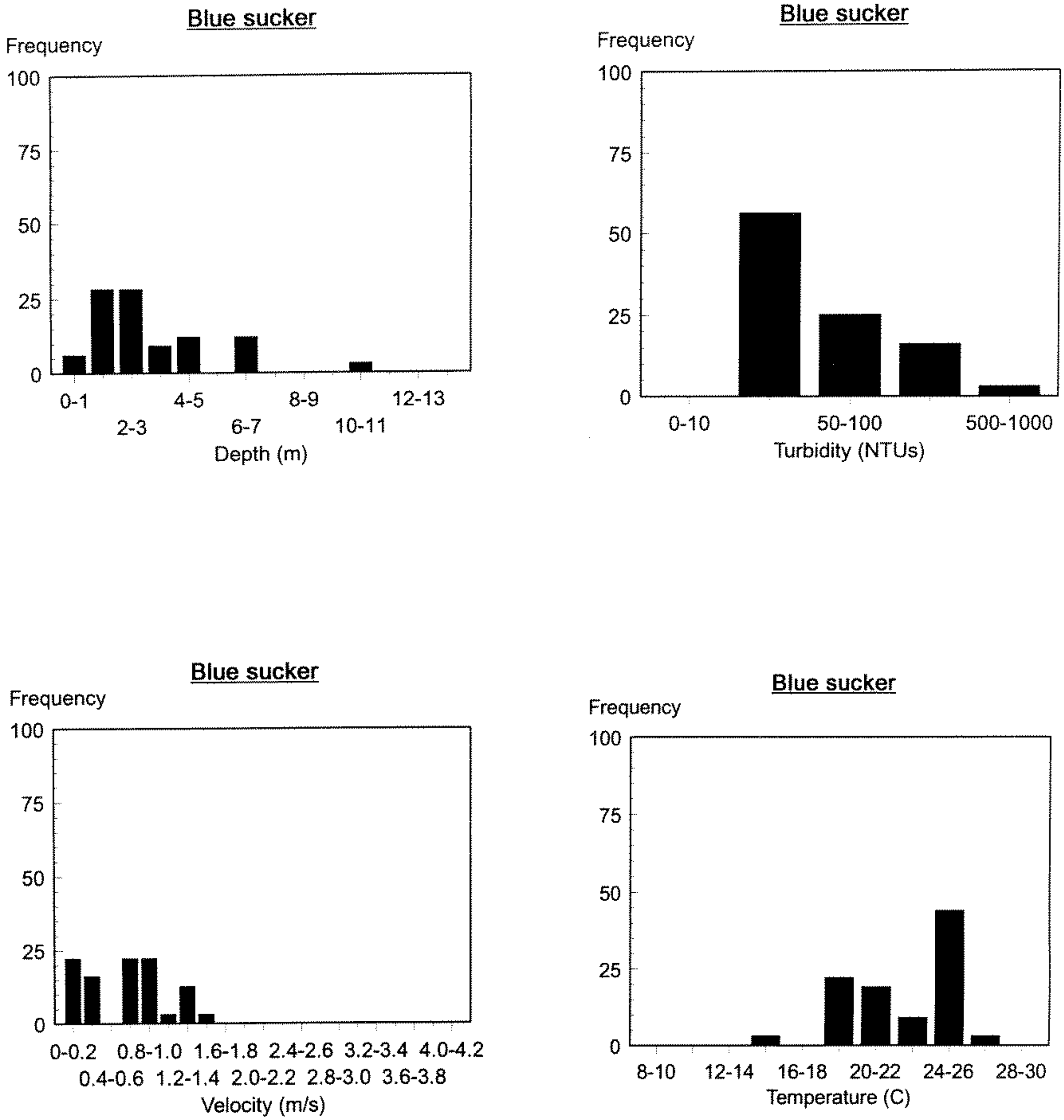


Figure 45. Frequency of occurrence of blue sucker (N=31) in various depth, velocity, turbidity, and water temperature intervals from Missouri and Lower Yellowstone River collections in 1996.

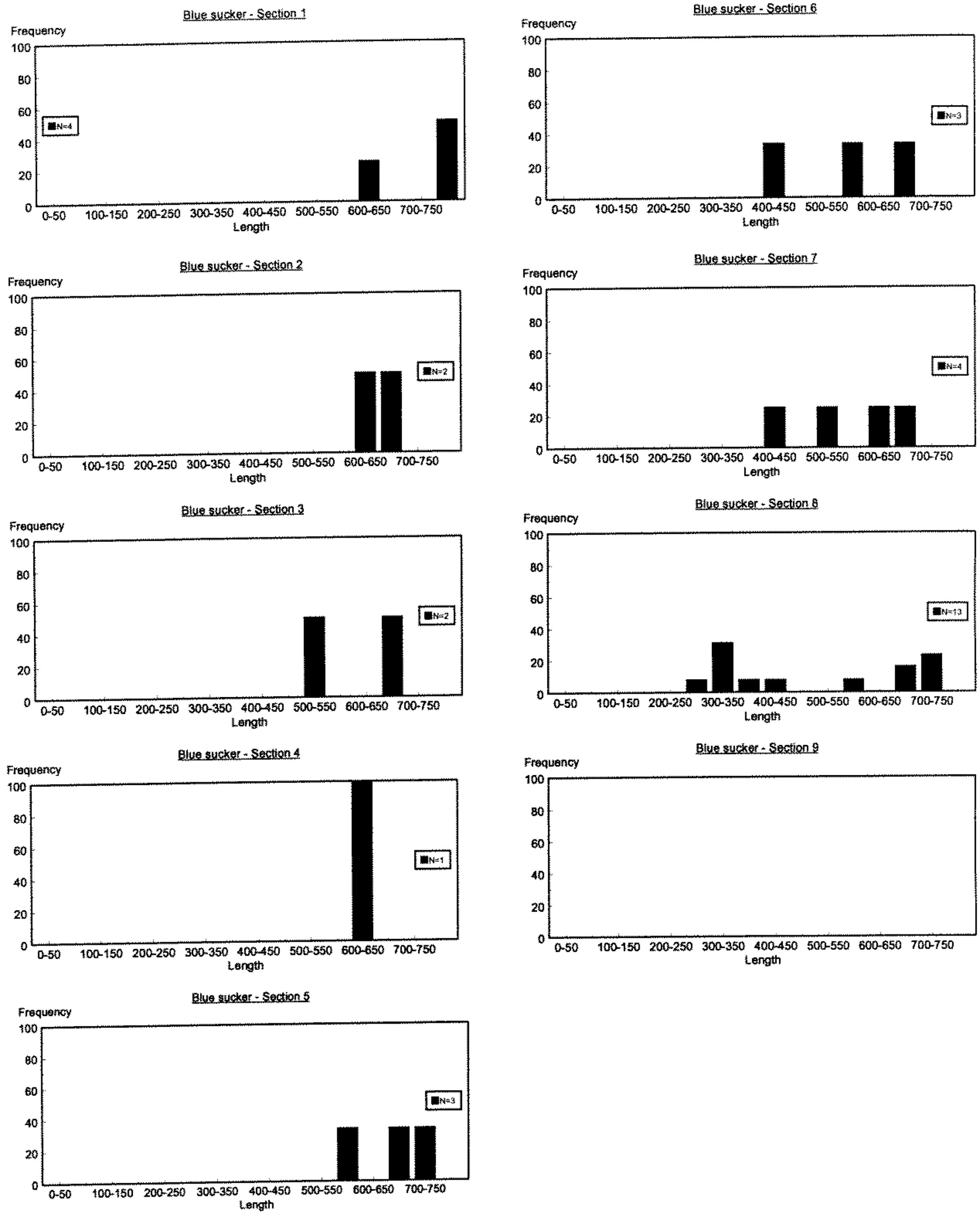


Figure 46. Length-frequency histograms of blue sucker collected in Missouri River study sections during 1996 by drifting trammel nets, experimental gill nets, a benthic trawl, bag seine, and boat electrofishing. Some lengths not presented as individuals were sent for age and growth analyses.

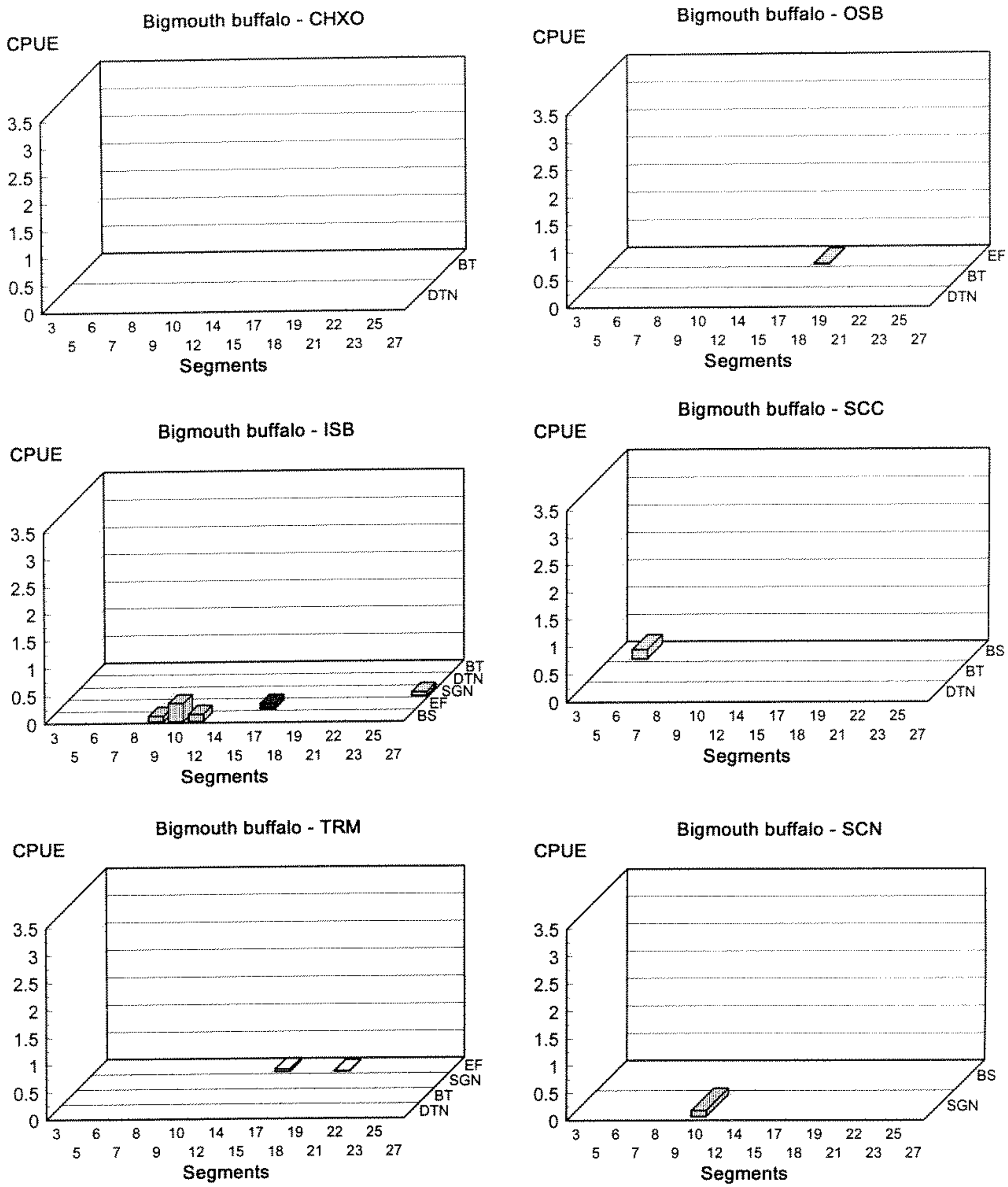


Figure 47. Trends in bigmouth buffalo catch rates among Missouri River study segments and macrohabitats in 1996. Catch rates for a benthic trawl (BT) and drifting trammel net (DTN) are #/100 m, for a bag seine (BS) - #/180 degree haul, experimental gill net (SGN) - #/hr, and electrofishing (EF) - #/min. See Appendix A for macrohabitat acronyms.

Table 33. Relative abundance of bigmouth buffalo collected in 18 Missouri River study segments in continuous macrohabitats (channel crossover-CHXO; outside bend-OSB; and inside bend-ISB) during 1996. Relative abundance in the various gears are #/100 m in drifting trammel nets (DTN) and a benthic trawl (BT); #/hr in stationary gill nets (SGN); #/min with boat electrofishing (EF); and #/180 degree shoreline haul with a bag seine (BS). A "-" indicates not sampled.

	CHXO		OSB			ISB				
Segment	BT	DTN	EF	BT	DTN	BS	SGN	EF	BT	DTN
3	-	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
6	0.00	0.00	-	-	-	0.00	-	-	-	-
7	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
9	0.00	0.00	-	0.00	0.00	0.10	0.00	-	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.33	-	-	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.13	-	-	-	-
14	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
17	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.10	0.00	0.00
18	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
21	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
23	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
27	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.00

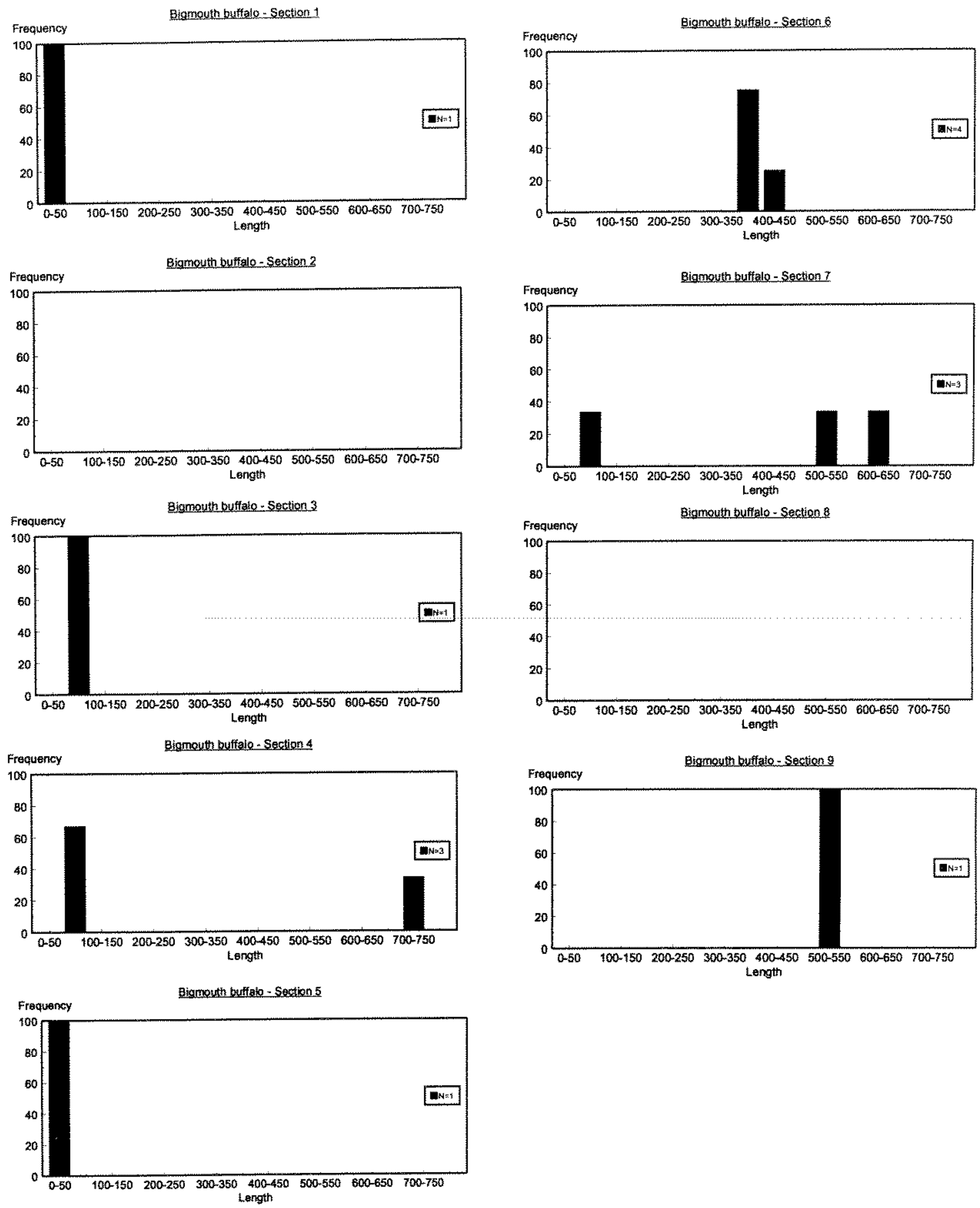


Figure 49. Length-frequency histograms of bigmouth buffalo collected in Missouri River study sections during 1996 by drifting trammel nets, experimental gill nets, a benthic trawl, bag seine, and boat electrofishing.

Smallmouth buffalo (SMBF)

Smallmouth buffalo (60 total) were collected in low numbers in all segments except **7**, **12**, *17*, *18*, and *19* (Figure 50; Tables 35 and 36). The greatest number (22) were captured in segment 3. They were not collected in CHXO's and the largest numbers were captured in TRMs and SCN, especially in channelized segments. Forty-nine percent were captured in least-impacted segments, 26% in inter-reservoir segments and 25% in channelized segments.

Like most species, smallmouth buffalo were generally collected in shallow depths and slow velocities (i.e., about 90% captured in depths < 2 m and velocities < 0.4 m/s) (Figure 51). Most (80%) were collected in moderately turbid waters (10-100 NTUs). No smallmouth buffalo were collected in turbidities < 10 NTUs. They were generally collected in warm waters (52% in temperatures between 20 and 22 °C), but 2 individuals were collected in temperatures between 10 and 14 °C.

Smallmouth buffalo lengths varied between 0-50 and 550-600 mm length intervals (Figure 52). The largest smallmouth buffalo (550-600 mm) were captured in sections 1, **2**, **6**, and *8*. Smallmouth buffalo < 50 mm which may indicate 1996 reproduction (Harlan and Speaker 1987), were captured in sections 1, **2**, and **6**.

River carpsucker (RVCS)

Seven-hundred-sixty-one river carpsucker were collected during 1996 in all segments and macrohabitats (Figure 53; Tables 37 and 38). The greatest numbers were collected in the Yellowstone River (i.e., 279 in segment 9) and the unchannelized reach downstream of Gavins Point Dam, SD/NE (i.e., 194 in segment **15**). In general, most river carpsucker were collected in discrete macrohabitats (SCN, TRMs and SCC), while few were captured in CHXOs. River carpsucker were generally captured in SCN in least-impacted and inter-reservoir segments. Conversely, most river carpsucker were collected in TRMs and ISB-BARS in channelized segments. Forty percent of river carpsuckers were captured in least-impacted segments followed by 35% in inter-reservoir segments and 25% in channelized segments. As stated above most river carpsucker in least-impacted and inter-reservoir segments were collected in only 2 segments while nearly equal numbers were collected in

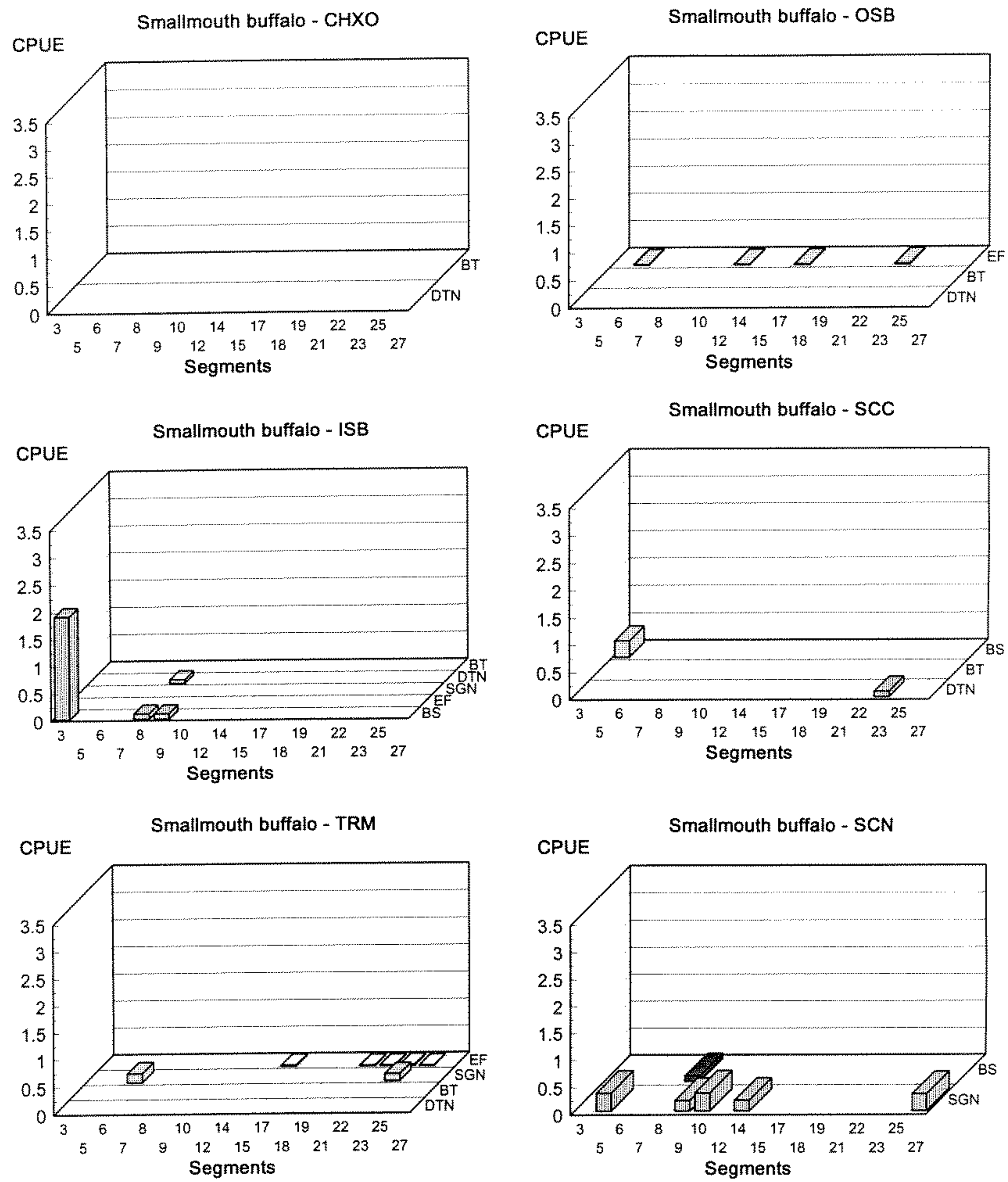


Figure 50. Trends of smallmouth buffalo catch rates among Missouri River study segments and macrohabitats in 1996. Catch rates for a benthic trawl (BT) and drifting trammel net (DTN) are #/100 m, for a bag seine (BS) - #/180 degree haul, experimental gill net (SGN) - #/hr, and electrofishing (EF) - #/min. See Appendix A for macrohabitat acronyms.

Table 35. Relative abundance of smallmouth buffalo collected in 18 Missouri River study segments in continuous macrohabitats (channel crossover-CHXO; outside bend-OSB; and inside bend-ISB) during 1996. Relative abundance in the various gears are #/100 m in drifting trammel nets (DTN) and a benthic trawl (BT); #/hr in stationary gill nets (SGN); #/min with boat electrofishing (EF); and #/180 degree shoreline haul with a bag seine (BS). A "-" indicates not sampled.

	CHXO		OSB			ISB				
Segment	BT	DTN	EF	BT	DTN	BS	SGN	EF	BT	DTN
3	-	0.00	0.00	-	0.00	1.90	-	-	-	0.00
5	0.00	0.00	0.01	0.00	0.00	0.00	-	0.00	0.00	0.00
6	0.00	0.00	-	-	-	0.00	-	-	-	-
7	0.00	0.00	-	0.00	0.00	0.00	-	-	0.00	0.00
8	0.00	0.00	-	0.00	0.00	0.10	0.00	-	0.00	0.07
9	0.00	0.00	-	0.00	0.00	0.10	0.00	-	0.00	0.00
10	0.00	0.00	0.01	0.00	0.00	0.00	-	-	0.00	0.00
12	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
15	0.00	0.00	0.01	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
18	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
21	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	0.01	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
25	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

Table 36. Relative abundance of smallmouth buffalo collected in 18 Missouri River study segments in discrete macrohabitats (secondary channels connected-SCC; secondary channels non-connected-SCN; tributary mouths-TRM) during 1996. Relative abundance in the various gears are #/100 m in drifting trammel nets (DTN) and a benthic trawl (BT); #/hr in stationary gill nets (SGN); #/min with boat electrofishing (EF); and #/180 degree shoreline haul with a bag seine (BS). A "-" indicates not sampled.

	SCC			SCN		TRM			
Segment	BT	DTN	BS	SGN	BS	EF	SGN	BT	DTN
3	-	-	0.30	-	-	-	-	-	-
5	0.00	0.00	0.00	0.33	0.00	-	-	-	-
6	-	-	0.00	0.00	0.00	-	0.17	-	-
7	0.00	0.00	0.00	0.00	0.00	-	0.00	-	-
8	0.00	0.00	0.00	0.00	0.10	-	0.00	-	-
9	0.00	0.00	0.00	0.19	0.00	-	-	-	-
10	0.00	0.00	0.00	0.33	0.00	-	-	-	-
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-
14	0.00	0.00	0.00	0.20	0.00	0.00	0.00	-	-
15	0.00	0.00	0.00	0.00	0.00	0.03	0.00	-	-
17	-	-	-	-	-	0.00	0.00	-	0.00
18	0.00	0.00	-	-	-	0.00	0.00	0.00	0.00
19	0.00	-	0.00	-	-	0.00	0.00	-	0.00
21	0.00	0.00	-	-	-	0.01	0.00	0.00	0.00
22	-	-	0.00	0.00	0.00	0.01	0.00	0.00	0.00
23	0.00	0.10	0.00	0.00	0.00	0.03	0.13	0.00	0.00
25	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
27	0.00	0.00	0.00	0.31	0.00	0.00	0.00	-	-

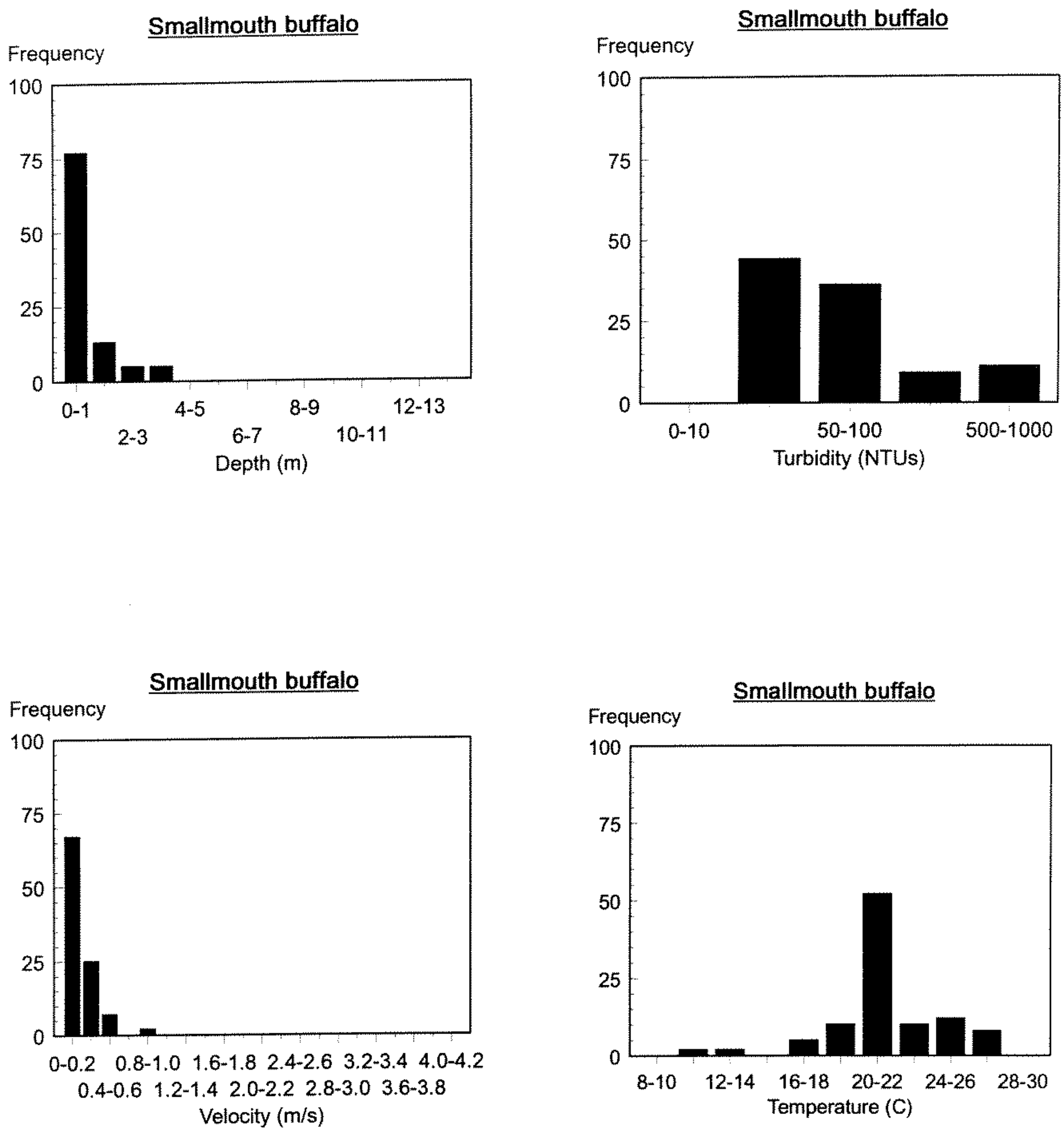


Figure 51. Frequency of occurrence of smallmouth buffalo (N=60) in various depth, velocity, turbidity, and water temperature intervals from Missouri and Lower Yellowstone River collections in 1996.

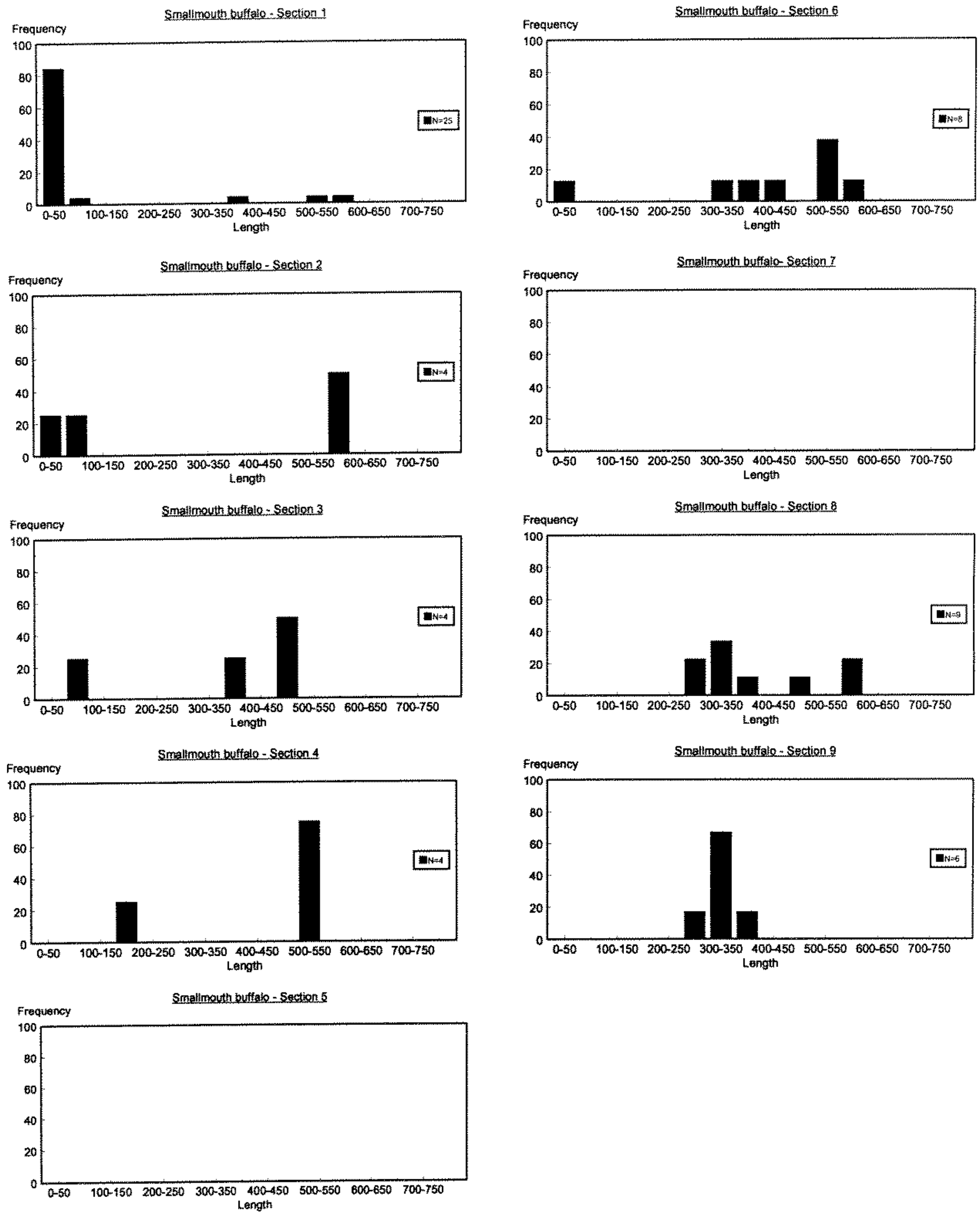


Figure 52. Length-frequency histograms of smallmouth buffalo collected in Missouri River study sections during 1996 by drifting trammel nets, experimental gill nets, a benthic trawl, bag seine, and boat electrofishing. Some lengths not presented as individuals were sent for age and growth analyses.

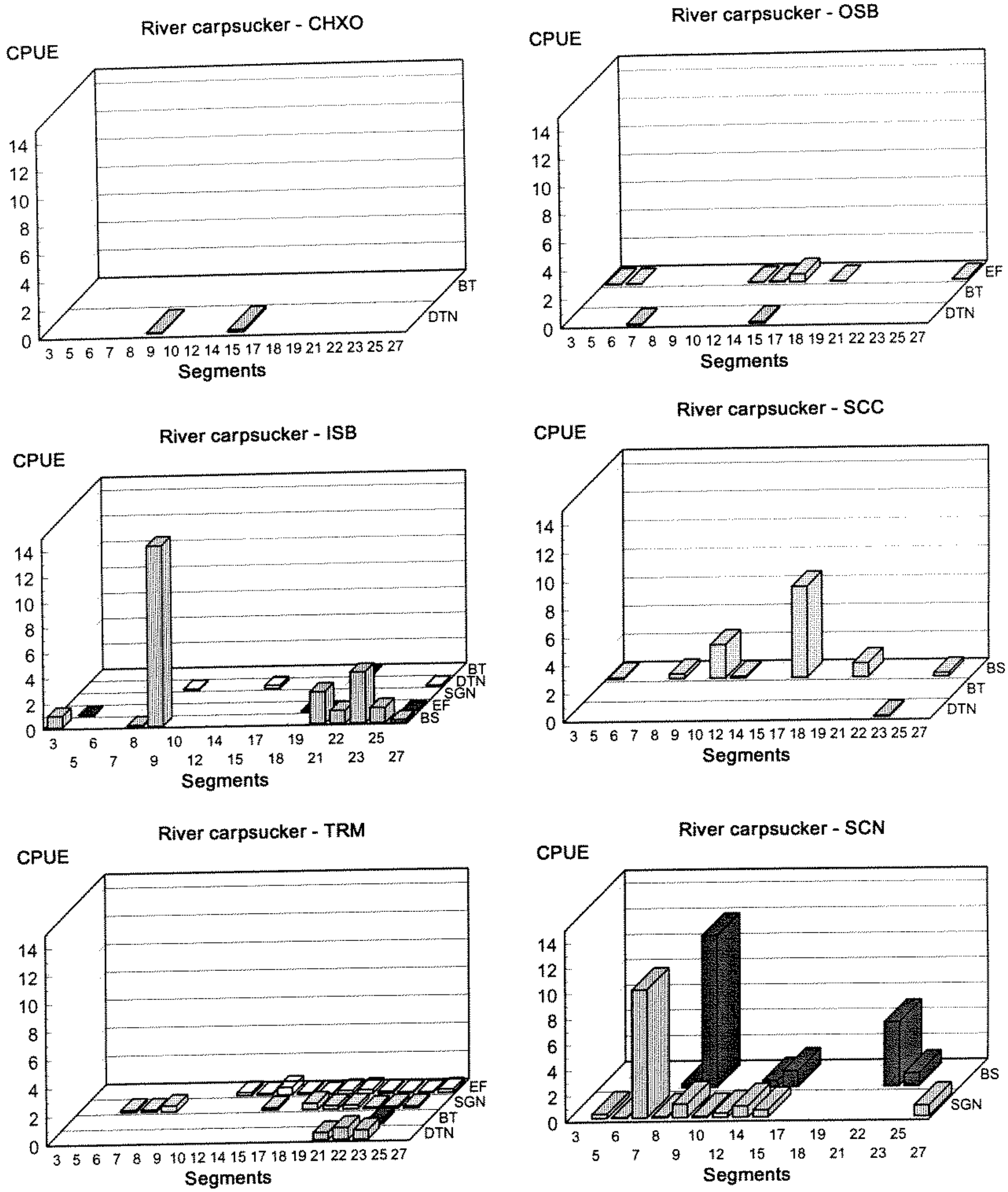


Figure 53. Trends of river carpsucker catch rates among Missouri River study segments and macrohabitats in 1996. Catch rates for a benthic trawl (BT) and drifting trammel net (DTN) are #/100 m, for a bag seine (BS) - #/180 degree haul, experimental gill net (SGN) - #/hr, and electrofishing (EF) - #/min. See Appendix A for macrohabitat acronyms.

Table 37. Relative abundance of river carpsucker collected in 18 Missouri River study segments in continuous macrohabitats (channel crossover-CHXO; outside bend-OSB; and inside bend-ISB) during 1996. Relative abundance in the various gears are #/100 m in drifting trammel nets (DTN) and a benthic trawl (BT); #/hr in stationary gill nets (SGN); #/min with boat electrofishing (EF); and #/180 degree shoreline haul with a bag seine (BS). A "-" indicates not sampled.

	CHXO		OSB			ISB				
Segment	BT	DTN	EF	BT	DTN	BS	SGN	EF	BT	DTN
3	-	0.00	0.05	-	0.00	0.90	-	-	-	0.00
5	0.00	0.00	0.03	0.00	0.00	0.00	-	0.05	0.00	0.00
6	0.00	0.00	-	-	-	0.00	-	-	-	-
7	0.00	0.00	-	0.00	0.07	0.00	-	-	0.00	0.00
8	0.00	0.00	-	0.00	0.00	0.10	0.00	-	0.00	0.00
9	0.00	0.07	-	0.00	0.00	14.20	0.00	-	0.00	0.08
10	0.00	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00
12	0.00	0.00	0.03	0.00	0.00	0.00	-	-	-	-
14	0.00	0.00	0.07	0.00	0.00	-	-	-	0.00	0.00
15	0.00	0.18	0.53	0.00	0.13	0.00	-	-	0.00	0.25
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.01	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	0.05	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	2.50	0.00	0.11	0.07	0.00
22	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.02	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	4.00	0.00	0.00	0.00	0.00
25	0.00	0.00	0.00	0.00	0.00	1.20	0.00	0.00	0.00	0.00
27	0.00	0.00	0.01	0.00	0.00	0.20	0.00	0.01	0.00	0.07

Table 38. Relative abundance of river carpsucker collected in 18 Missouri River study segments in discrete macrohabitats (secondary channels connected-SCC; secondary channels non-connected-SCN; tributary mouths-TRM) during 1996. Relative abundance in the various gears are #/100 m in drifting trammel nets (DTN) and a benthic trawl (BT); #/hr in stationary gill nets (SGN); #/min with boat electrofishing (EF); and #/180 degree shoreline haul with a bag seine (BS). A "-" indicates not sampled.

	SCC			SCN		TRM			
Segment	BT	DTN	BS	SGN	BS	EF	SGN	BT	DTN
3	-	-	0.10	-	-	-	-	-	-
5	0.00	0.00	0.00	0.33	0.00	-	-	-	-
6	-	-	0.00	0.07	0.00	-	0.17	-	-
7	0.00	0.00	0.33	10.00	0.00	-	0.16	-	-
8	0.00	0.00	0.00	0.12	0.00	-	0.43	-	-
9	0.00	0.00	2.40	1.05	11.90	-	-	-	-
10	0.00	0.00	0.13	0.11	0.00	-	-	-	-
12	0.00	0.00	0.00	0.33	0.00	0.20	0.00	-	-
14	0.00	0.00	0.00	0.88	0.50	0.12	0.00	-	-
15	0.00	0.00	6.50	0.56	1.25	0.53	0.17	-	-
17	-	-	-	-	-	0.14	0.00	-	0.00
18	0.00	0.00	-	-	-	0.05	0.46	0.00	0.00
19	0.00	-	1.00	-	-	0.24	0.25	-	0.00
21	0.00	0.00	-	-	-	0.29	0.27	0.00	0.50
22	-	-	0.00	0.00	5.00	0.15	0.10	0.00	0.85
23	0.00	0.10	0.00	0.00	1.00	0.10	0.18	0.33	0.67
25	0.00	0.00	0.25	0.00	0.00	0.07	0.16	0.00	0.00
27	0.00	0.00	0.00	0.87	0.00	0.24	0.00	-	-

channelized segments (Table 11). This may suggest that river carpsucker are a common species in channelized segments.

River carpsucker generally used shallow depths (81% in depths < 1 m) and slow velocities (86% in velocities < 0.2 m/s) (Figure 54). They were collected in turbidities ranging from 0 to > 1,000 NTUs, but the largest number (75%) were captured in moderately clear waters (10-50 NTUs). In general, river carpsucker were captured in warm water temperatures (95% in temperatures between 20 and 30 °C), but 2% were collected in temperatures from 10-16 °C.

River carpsucker lengths varied between 0-50 and 550-600 mm length intervals (Figure 55). The largest river carpsucker (550-600 mm) was captured in section *8* (rmi 498-220, KS/MO). Natural reproduction as suggested by 0-50 mm long individuals (Pflieger 1975) was evident in all sections except **5** (i.e., Garrison Dam to the headwaters of Lake Oahe, ND).

White sucker (WTSK)

Three-hundred-eighty-nine white suckers were captured, but only in the upper 750 river miles (i.e., least-impacted and inter-reservoir segments upstream of and including segment **12**) (Figure 56). Most were collected in secondary channels (SCC-SHLW and SCN) with the bag seine. In order from greatest frequency of occurrence, they were collected by bag seining in SCC-SHLW, ISB-BARS, and SCN. Few white suckers were collected by benthic trawling, electrofishing, and gill netting (Tables 39 and 40). However, they were captured in a WILD macrohabitat (i.e., Garrison Dam tailrace) in segment **12** with a gill net catch rate of 1.0/hr. Ninty-one percent were captured in inter-reservoir segments leaving 9% captured in least-impacted segment 3.

White sucker were generally collected in shallow depths (95% in depths < 1 m), slow velocities (< 0.4 m/s), and clear (< 50 NTUs), cool water (82% in water temperatures < 20 °C) (Figure 57). Shallow depths, slow velocities and reduced turbidities are characteristic of secondary channels (see physicochemcial section) where most white sucker were collected

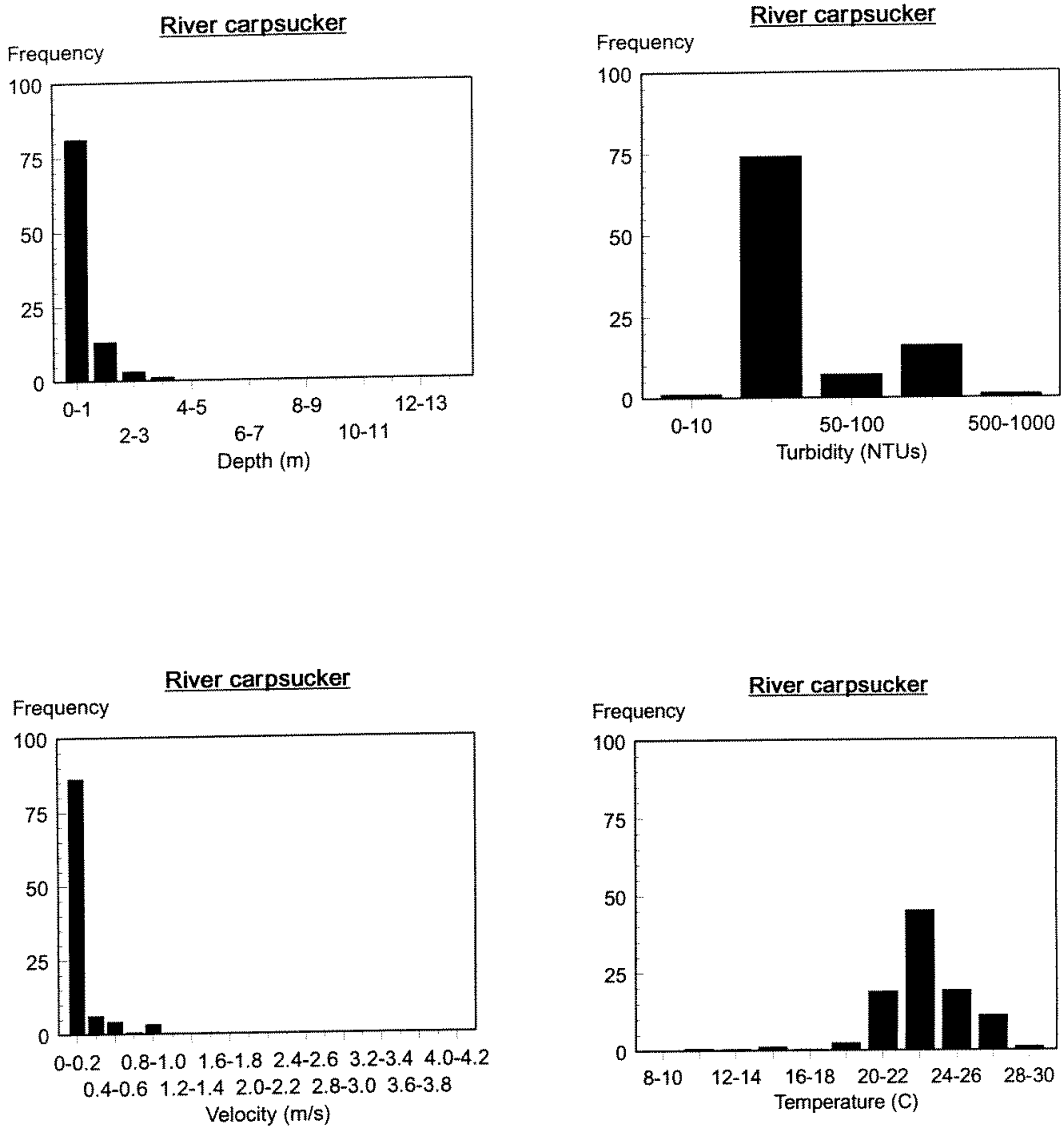


Figure 54. Frequency of occurrence of river carpsucker (N=761) in various depth, velocity, turbidity, and water temperature intervals from Missouri and Lower Yellowstone River collections in 1996.

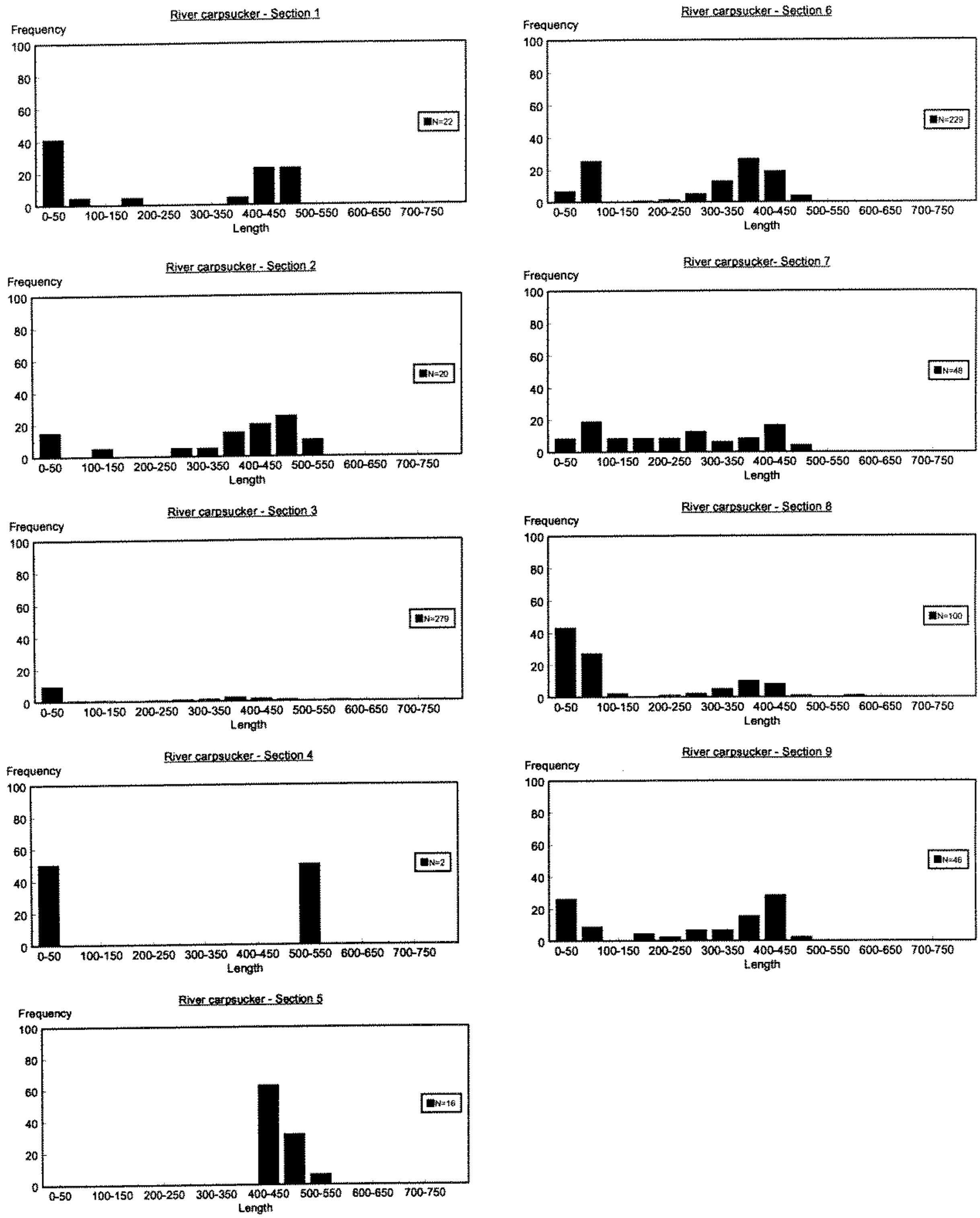


Figure 55. Length-frequency histograms of river carpsucker collected in Missouri River study sections during 1996 by drifting trammel nets, experimental gill nets, a benthic trawl, bag seine, and boat electrofishing. Some lengths not presented as individuals were sent for age and growth analyses.

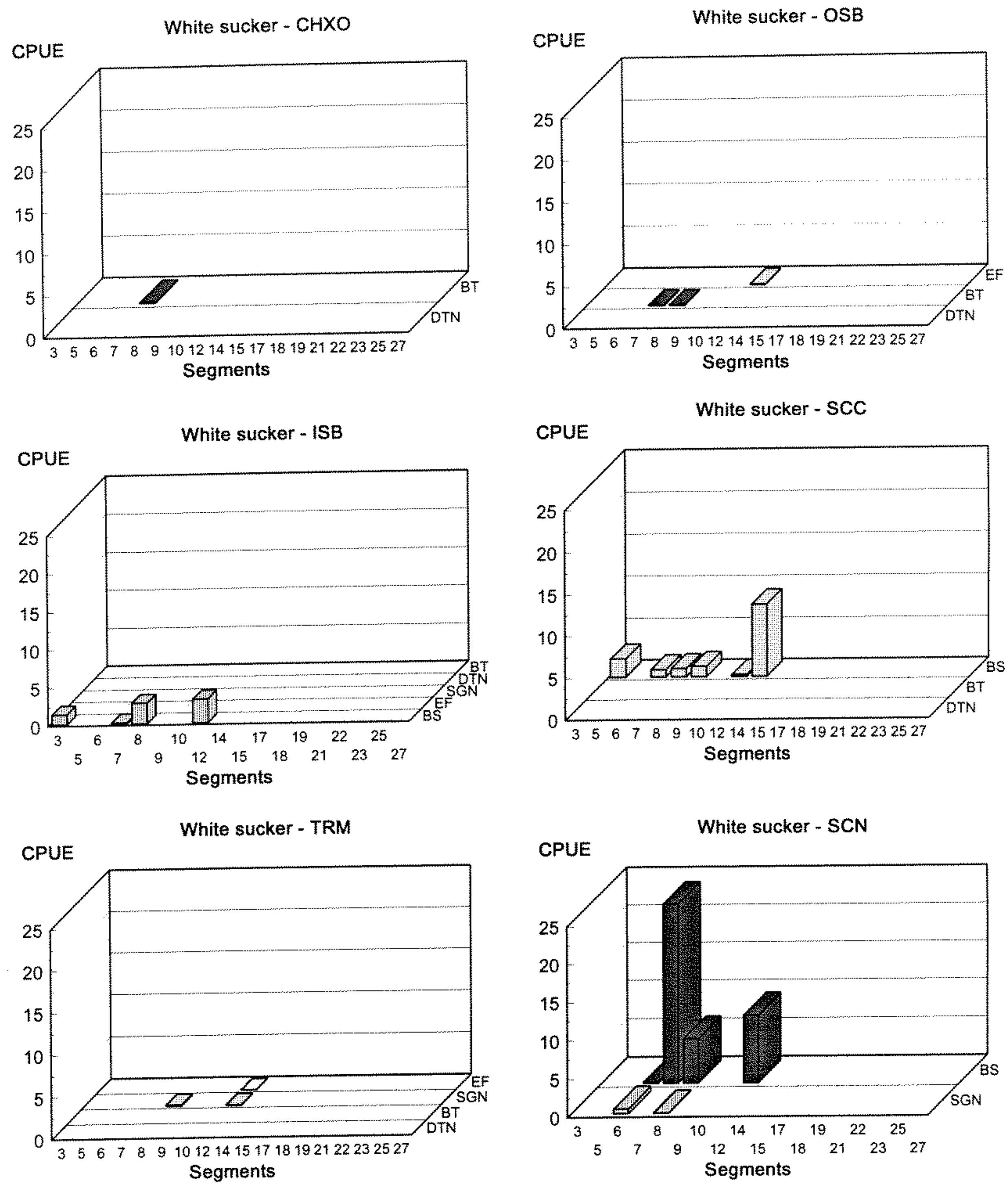


Figure 56. Trends in white sucker catch rates among Missouri River study segments and macrohabitats in 1996. Catch rates for a benthic trawl (BT) and drifting trammel net (DTN) are #/100 m, for a bag seine (BS) - #/180 degree haul, experimental gill net (SGN) - #/hr, and electrofishing (EF) - #/min. See Appendix A for macrohabitat acronyms.

Table 39. Relative abundance of white sucker collected in 18 Missouri River study segments in continuous macrohabitats (channel crossover-CHXO; outside bend-OSB; and inside bend-ISB) during 1996. Relative abundance in the various gears are #/100 m in drifting trammel nets (DTN) and a benthic trawl (BT); #/hr in stationary gill nets (SGN); #/min with boat electrofishing (EF); and #/180 degree shoreline haul with a bag seine (BS). A "-" indicates not sampled.

	CHXO		OSB			ISB				
Segment	BT	TN	EF	BT	DTN	BS	SGN	EF	BT	DTN
3	-	0.00	0.00	-	0.00	1.30	-	-	-	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	-	0.00	0.00	0.00
6	0.00	0.00	-	-	-	0.00	-	-	-	-
7	0.07	0.00	-	0.07	0.00	0.17	-	-	0.00	0.00
8	0.00	0.00	-	0.07	0.00	2.70	0.00	-	0.00	0.00
9	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
12	0.00	0.00	0.12	0.00	0.00	3.13	-	-	-	-
14	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
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	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
21	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
23	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
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 40. Relative abundance of white sucker collected in 18 Missouri River study segments in discrete macrohabitats (secondary channels connected-SCC; secondary channels non-connected-SCN; tributary mouths-TRM) during 1996. Relative abundance in the various gears are #/100 m in drifting trammel nets (DTN) and a benthic trawl (BT); #/hr in stationary gill nets (SGN); #/min with boat electrofishing (EF); and #/180 degree shoreline haul with a bag seine (BS). A "-" indicates not sampled.

		SCC		SCN		TRM			
Segment	BT	DTN	BS	SGN	BS	EF	SGN	BT	DTN
3	-	-	2.20	-	-	-	-	-	-
5	0.00	0.00	0.00	0.00	0.00	-	-	-	-
6	-	-	0.90	0.60	0.10	-	0.00	-	-
7	0.00	0.00	1.00	0.00	23.50	-	0.00	-	-
8	0.00	0.00	1.25	0.07	5.80	-	0.16	-	-
9	0.00	0.00	1.30	0.00	0.00	-	-	-	-
10	0.00	0.00	0.25	0.00	0.00	-	-	-	-
12	0.00	0.00	8.67	0.00	8.80	0.03	0.08	-	-
14	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	-	-
17	-	-	-	-	-	0.00	0.00	-	0.00
18	0.00	0.00	-	-	-	0.00	0.00	0.00	0.00
19	0.00	-	0.00	-	-	0.00	0.00	-	0.00
21	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
23	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
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-

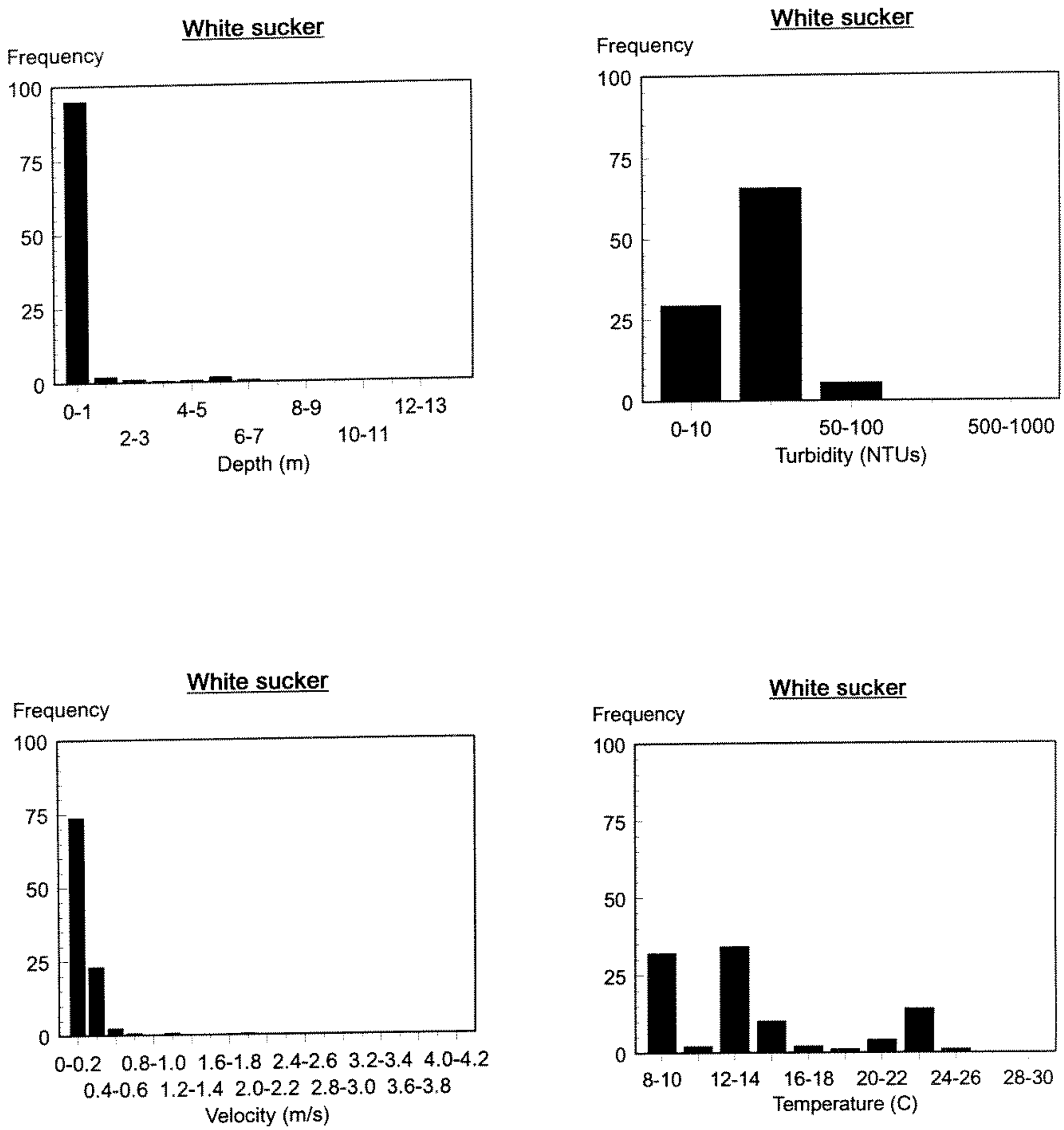


Figure 57. Frequency of occurrence of white sucker (N=309) in various depth, velocity, turbidity, and water temperature intervals from Missouri and Lower Yellowstone River collections in 1996.

from. Also, most white sucker were collected with the bag seine which only samples shallow water (i.e., < 1.2 m) and in inter-reservoir segments where turbidity is reduced.

White sucker lengths varied between 0-50 and 500-550 mm length intervals with most < 50 mm (Figure 58). The larger white suckers were captured between Garrison Dam and the headwaters of Lake Oahe in North Dakota (i.e., section **5**) with maximum lengths of 550 mm. White sucker exceeded 150 mm in sections **2** and **5**.

Shorthead redhorse (SHRH)

One-hundred-ninety-five shorthead redhorse were collected in all gears. Most were captured in ISBs, OSBs, and SCCs and none in CHXOs (Figure 59). Few were collected with the benthic trawl and only in ISB-CHNBs (Tables 41 and 42). Non-standardized electrofishing procedures yielded the following catch rates; 0.05/min in segment **14** SCC-DEEP and 0.08/min in segment **15** SCN (i.e., cattail marshes below Gavins Point Dam, South Dakota/Nebraska where seining was impossible). Most (61%) were collected in least-impacted segments, followed by 38% in inter-reservoir segments, and only 1% in channelized segments. They were not collected downstream of segment *21* (rmi 498-440).

Shorthead redhorse were generally captured in shallow depths (60% in depths < 1 m), and moderate velocities (50% in 0.2 to 0.6 m/s) (Figure 60). Many (85%) were captured in turbidities < 50 NTUs and water temperatures between 18 and 26 °C.

Shorthead redhorse lengths varied between 0-50 and 500-550 mm length intervals, but most were generally < 350 mm (Figure 61). Shorthead redhorse > 350 mm were only collected in sections 1, **2**, **5** and **6**, and no shorthead redhorse were captured in the lowest 220 river miles (i.e., section *9*). Only in sections 1 and **6** were enough specimens collected to show a size distribution with some continuity, which appeared to include 2-3 age groups.

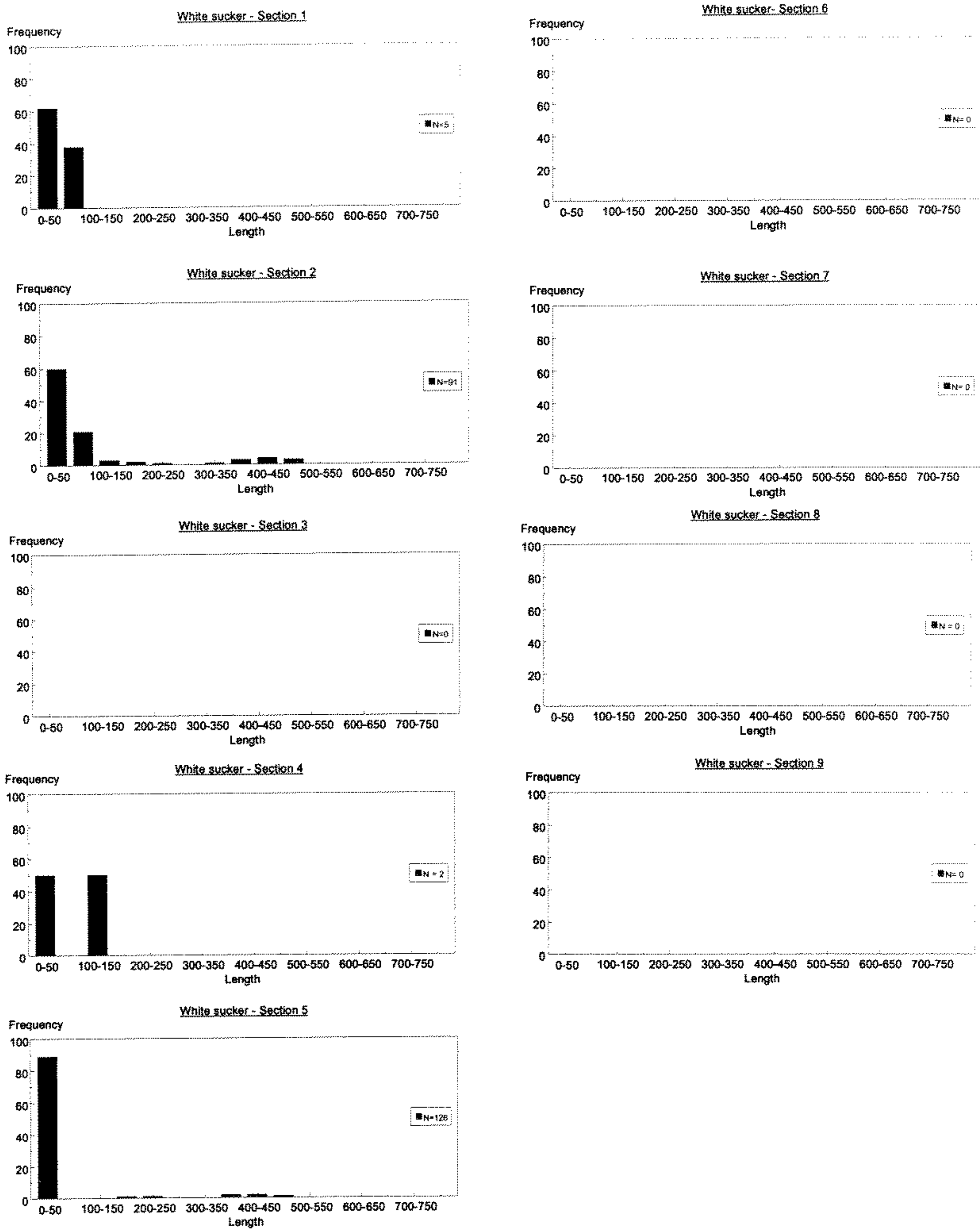


Figure 58. Length-frequency histograms of white sucker collected in Missouri River study sections during 1996 by drifting trammel nets, experimental gill nets, a benthic trawl, bag seine, and boat electrofishing.

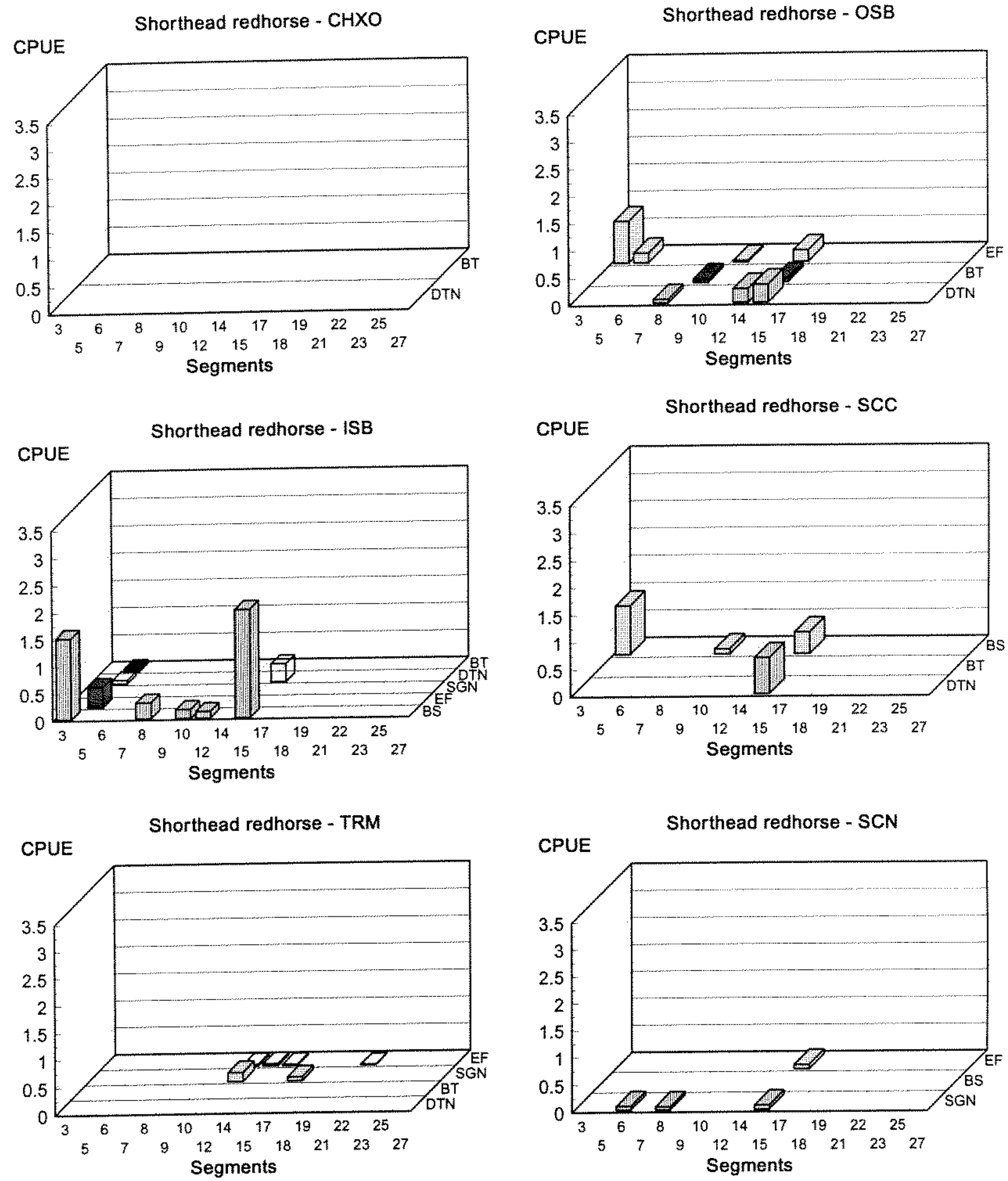


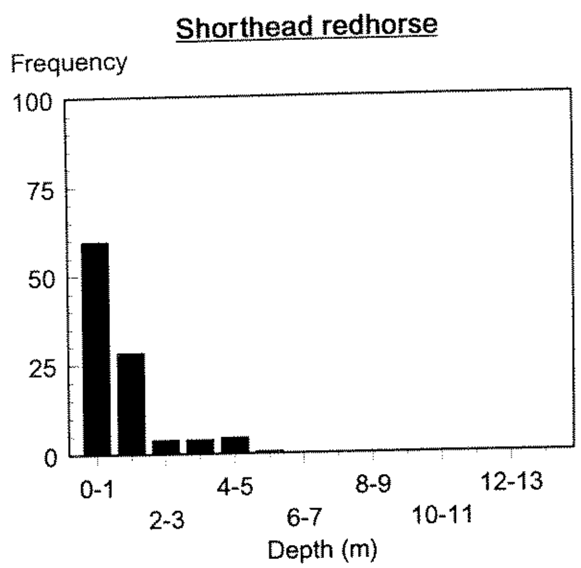
Figure 59. Trends in shorthead redhorse catch rates among Missouri River study segments and macrohabitats in 1996. Catch rates for a benthic trawl (BT) and drifting trammel net (DTN) are #/100 m, for a bag seine (BS) - #/180 degree haul, experimental gill net (SGN) - #/hr, and electrofishing (EF) - #/min. See Appendix A for macrohabitat acronyms.

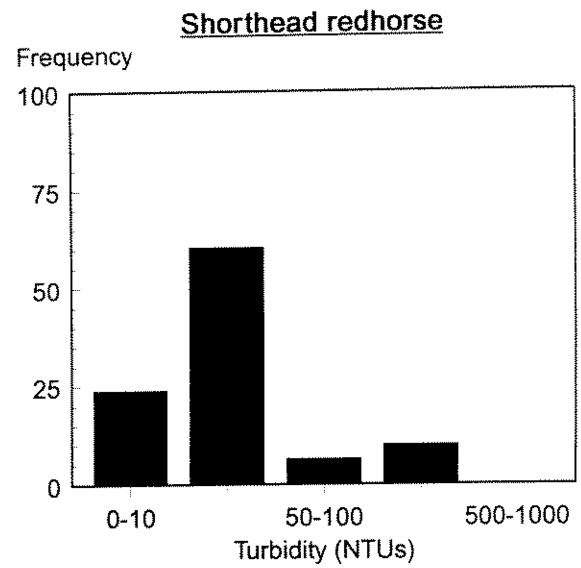
Table 41. Relative abundance of shorthead redhorse collected in 18 Missouri River study segments in continuous macrohabitats (channel crossover-CHXO; outside bend-OSB; and inside bend-ISB) during 1996. Relative abundance in the various gears are #/100 m in drifting trammel nets (DTN) and a benthic trawl (BT); #/hr in stationary gill nets (SGN); #/min with boat electrofishing (EF); and #/180 degree shoreline haul with a bag seine (BS). A "-" indicates not sampled.

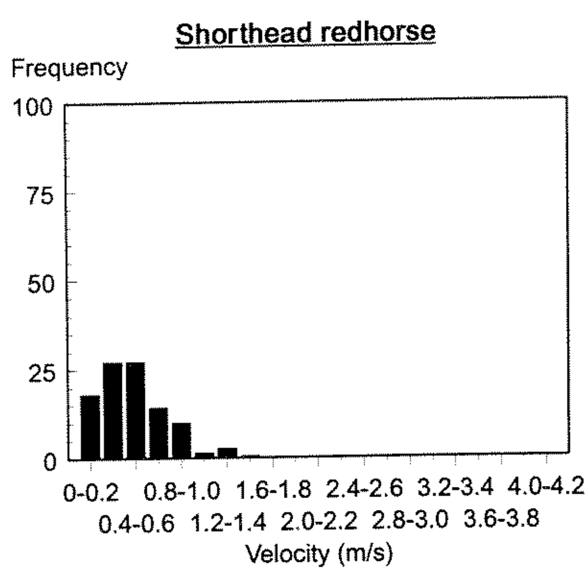
	CHXO		OSB			ISB				
Segment	BT	DTN	EF	BT	DTN	BS	SGN	EF	BT	DTN
3	-	0.00	0.77	-	0.00	1.50	-	-	-	0.00
5	0.00	0.00	0.17	0.00	0.00	0.00	-	0.39	0.07	0.07
6	0.00	0.00	-	-	-	0.00	-	-	-	-
7	0.00	0.00	-	0.00	0.00	0.00	-	-	0.00	0.00
8	0.00	0.00	-	0.00	0.07	0.30	0.00	-	0.00	0.00
9	0.00	0.00	-	0.07	0.00	0.00	0.00	-	0.00	0.00
10	0.00	0.00	0.03	0.00	0.00	0.17	-	-	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.13	-	-	-	-
14	0.00	0.00	0.00	0.00	0.25	-	-	-	0.00	0.00
15	0.00	0.00	0.21	0.07	0.33	2.00	-	-	0.00	0.33
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	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
21	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
23	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
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 42. Relative abundance of shorthead redhorse collected in 18 Missouri River study segments in discrete macrohabitats (secondary channels connected-SCC; secondary channels non-connected-SCN; tributary mouths-TRM) during 1996. Relative abundance in the various gears are #/100 m in drifting trammel nets (DTN) and a benthic trawl (BT); #/hr in stationary gill nets (SGN); #/min with boat electrofishing (EF); and #/180 degree shoreline haul with a bag seine (BS). A "-" indicates not sampled.

	SCC			SCN		TRM			
Segment	BT	DTN	BS	SGN	BS	EF	SGN	BT	DTN
3	-	-	0.90	-	-	-	-	-	-
5	0.00	0.00	0.00	0.00	0.00	-	-	-	-
6	-	-	0.00	0.07	0.00	-	0.00	-	-
7	0.00	0.00	0.00	0.00	0.00	-	0.00	-	-
8	0.00	0.00	0.00	0.06	0.00	-	0.00	-	-
9	0.00	0.00	0.10	0.00	0.00	-	-	-	-
10	0.00	0.00	0.00	0.00	0.00	-	-	-	-
12	0.00	0.00	0.00	0.00	0.00	0.03	0.17	-	-
14	0.00	0.00	0.00	0.00	0.00	0.04	0.00	-	-
15	0.00	0.67	0.40	0.08	0.00	0.03	0.00	-	-
17	-	-	-	-	-	0.00	0.07	-	0.00
18	0.00	0.00	-	-	-	0.00	0.00	0.00	0.00
19	0.00	-	0.00	-	-	0.00	0.00	-	0.00
21	0.00	0.00	-	-	-	0.01	0.00	0.00	0.00
22	-	-	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
25	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	-	-







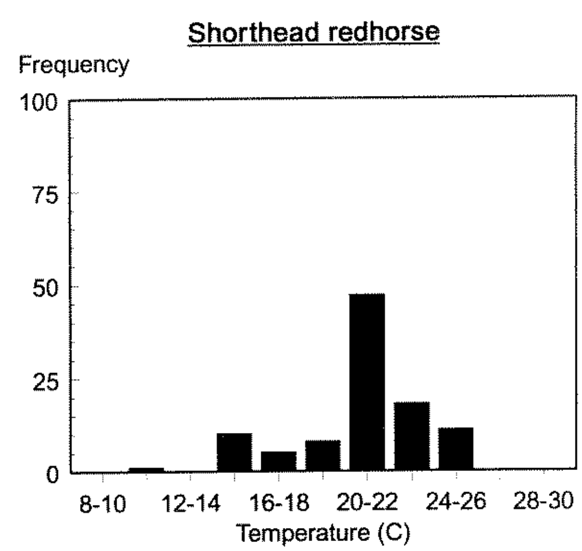


Figure 60. Frequency of occurrence of shorthead redhorse (N=195) in various depth, velocity, turbidity, and water temperature intervals from Missouri and Lower Yellowstone River collections in 1996.

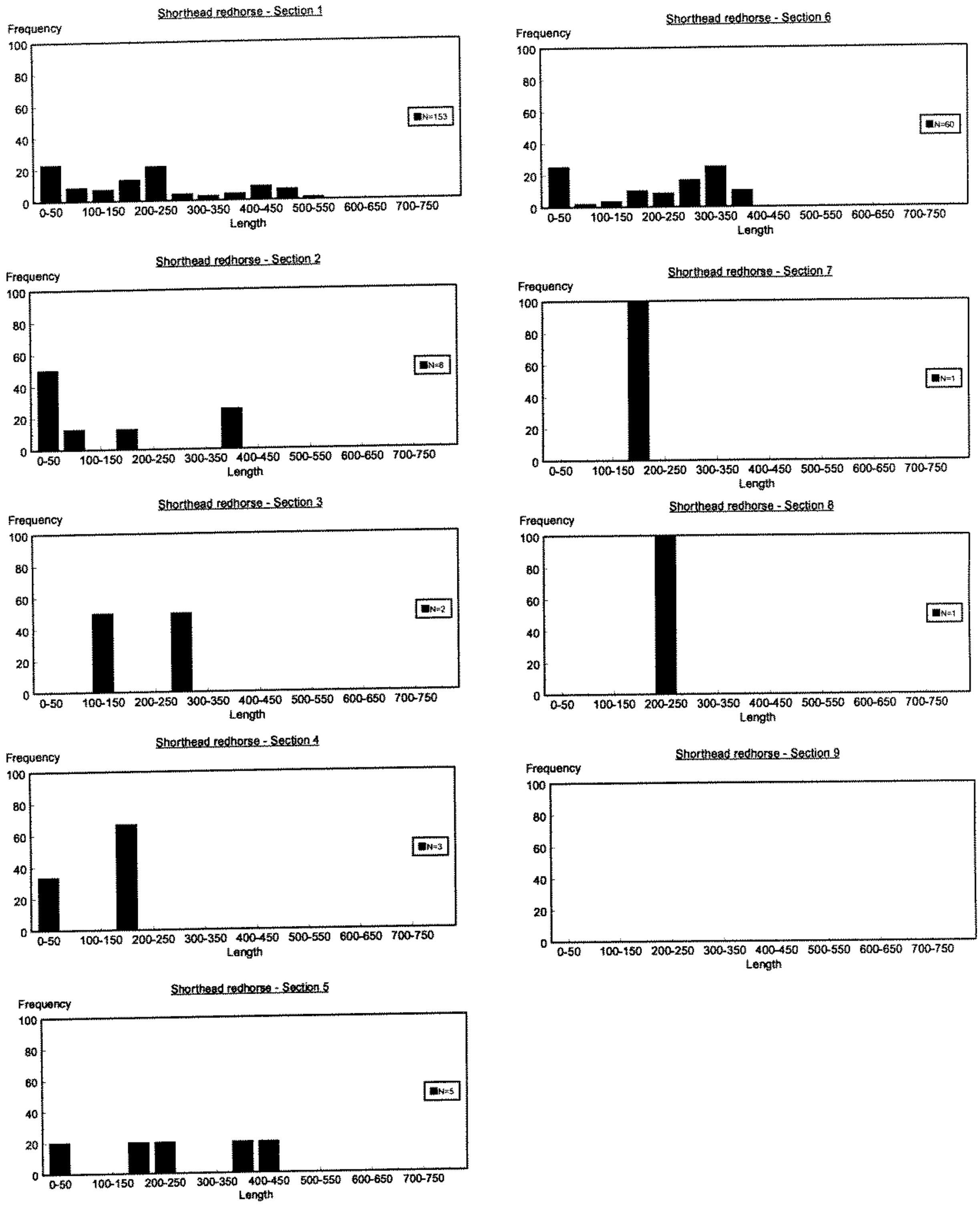


Figure 61. Length-frequency histograms of shorthead redhorse collected in Missouri River study sections during 1996 by drifting trammel nets, experimental gill nets, a benthic trawl, bag seine, and boat electrofishing.

Channel catfish (CNCF)

Channel catfish were commonly collected (990 individuals collected) in all segments, except **6** (immediately downstream of Fort Peck Dam) where none were captured (Figure 62). They were collected in all gears and all macro- and meso-habitats including WILD, with most in ISBs and SCCs (Tables 43 and 44). A bag seine catch rate in segment **14** WILD macrohabitat (i.e., TRM-SMLL-Niobrara River mouth, which was too shallow to electrofish) was 7.0/haul. In a segment **12** WILD macrohabitat (i.e., Garrison Dam tailwaters), the trammel net catch rate was 0.67/100 m drift. Eighty-one percent were captured in channelized segments, 8% in inter-reservoir segments, and 11% in least-impacted segments.

Channel catfish were generally found in moderate to shallow depths (90% in depths < 4 m), moderate to slow velocities (75% in velocities < 0.6 m/s), moderate turbidities (75% in turbidities from 10-500 NTUs), and warm water temperatures (77% in temperatures between 24 and 28 °C) (Figure 63). Less than 5% of channel catfish collections were in turbidities < 10 NTUs, and water temperatures < 18 °C.

Most channel catfish captured were < 300 mm total length and varied between 0-50 and 750-800 mm length intervals (Figure 64). Declining length frequencies in sections *7*, *8*, and *9*, all channelized, suggests good reproduction and consistent recruitment or problems sampling larger channel catfish. Sections 1 to **5** show irregular length-frequency patterns suggesting erratic recruitment or juveniles were not yet recruited to gears. Also, many of these sections had sample sizes too small (i.e., < 100 individuals as recommended by Anderson and Neumann 1996) to adequately assess population characteristics based solely on length-frequency histograms.

Blue catfish (BLCF)

One-hundred-three blue catfish were collected only in channelized segments *22, 23, 25,* and *27* (i.e., rmi 440.0-0.0) in all gears except drifting trammel nets, and in all macro- and meso-habitats except TRM-LRGE (Figure 65; Tables 45 and 46). Most were collected in ISBs and SCC with bag seines and the benthic trawl. In order from greatest frequency of occurance, blue catfish were captured with the benthic trawl in ISB-CHNBs,

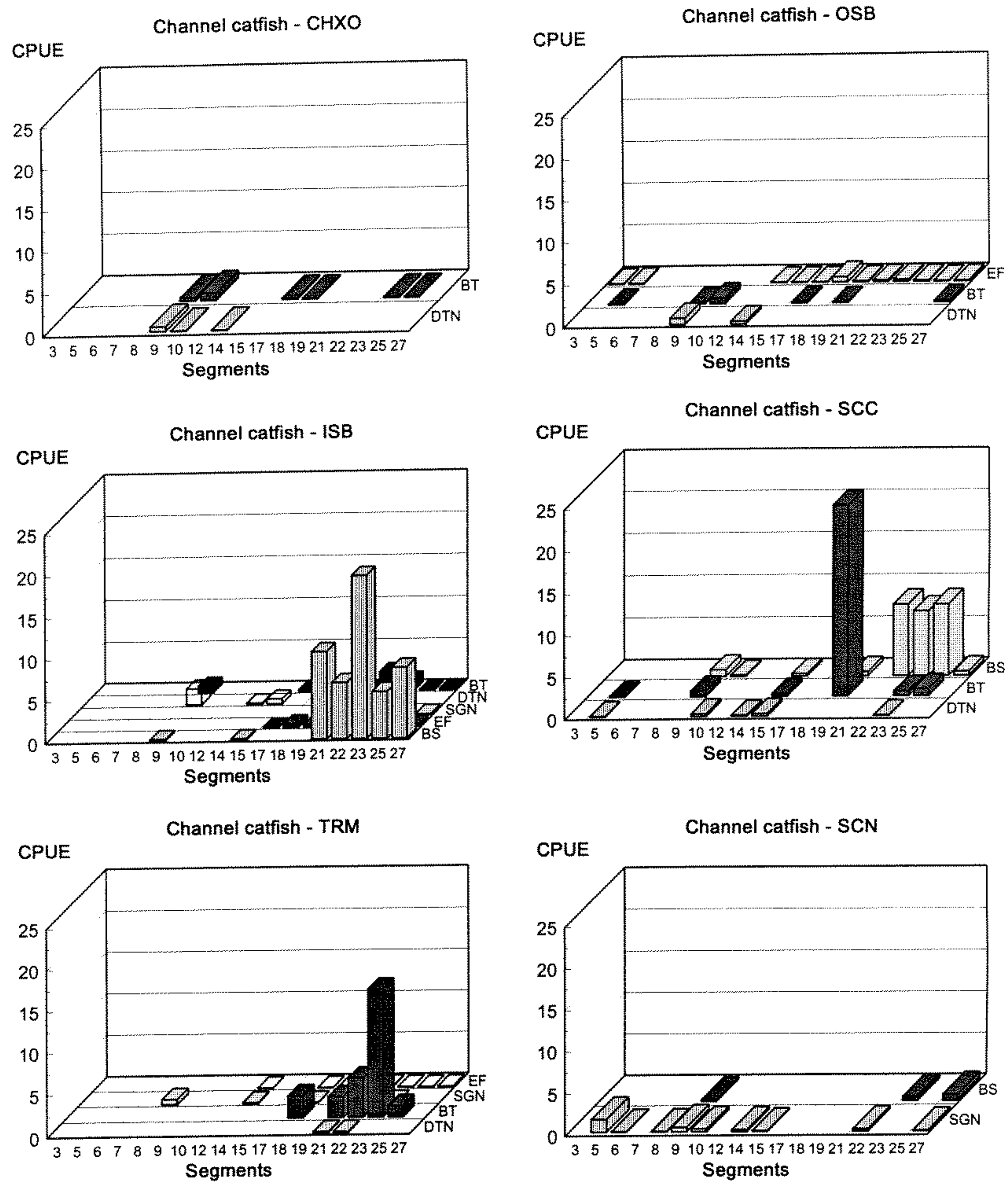


Figure 62. Trends of channel catfish catch rates among Missouri River study segments and macrohabitats in 1996. Catch rates for a benthic trawl (BT) and drifting trammel net (DTN) are #/100 m, for a bag seine (BS) - #/180 degree haul, experimental gill net (SGN) - #/hr, and electrofishing (EF) - #/min. See Appendix A for macrohabitat acronyms.

Table 43. Relative abundance of channel catfish collected in 18 Missouri River study segments in continuous macrohabitats (channel crossover-CHXO; outside bend-OSB; and inside bend-ISB) during 1996. Relative abundance in the various gears are #/100 m in drifting trammel nets (DTN) and a benthic trawl (BT); #/hr in stationary gill nets (SGN); #/min with boat electrofishing (EF); and #/180 degree shoreline haul with a bag seine (BS). A "-" indicates not sampled.

	CHXO		OSB			ISB				
Segment	BT	DTN	EF	BT	DTN	BS	SGN	EF	BT	DTN
3	-	0.00	0.10	-	0.00	0.00	-	-	-	0.00
5	0.00	0.00	0.13	0.07	0.00	0.00	-	0.01	0.00	0.00
6	0.00	0.00	-	-	-	0.00	-	-	-	-
7	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
9	0.40	0.57	-	0.13	0.73	0.20	0.00	-	0.83	1.92
10	0.87	0.07	0.00	0.67	0.00	0.00	-	-	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	-	-	-	-
14	0.00	0.07	0.02	0.00	0.33	-	-	-	0.00	0.13
15	0.00	0.00	0.04	0.00	0.00	0.17	-	-	0.00	0.58
17	0.13	0.00	0.04	0.13	0.00	0.00	0.00	0.10	0.27	0.00
18	0.01	0.00	0.64	0.00	0.00	-	0.00	0.45	0.13	0.00
19	0.00	0.00	0.12	0.07	0.00	-	0.00	0.30	0.13	0.00
21	0.00	0.00	0.21	0.00	0.00	10.50	0.00	0.31	0.13	0.00
22	0.00	0.00	0.25	0.00	0.00	6.75	0.00	0.14	2.27	0.00
23	0.07	0.00	0.16	0.00	0.00	19.50	0.00	0.24	1.20	0.07
25	0.07	0.00	0.08	0.00	0.00	5.60	0.00	0.16	0.07	0.00
27	0.00	0.00	0.13	0.13	0.00	8.50	0.06	0.20	0.20	0.00

Table 44. Relative abundance of channel catfish collected in 18 Missouri River study segments in discrete macrohabitats (secondary channels connected-SCC; secondary channels non-connected-SCN; tributary mouths-TRM) during 1996. Relative abundance in the various gears are #/100 m in drifting trammel nets (DTN) and a benthic trawl (BT); #/hr in stationary gill nets (SGN); #/min with boat electrofishing (EF); and #/180 degree shoreline haul with a bag seine (BS). A "-" indicates not sampled.

	SCC			SCN		TRM			
Segment	BT	DTN	BS	SGN	BS	EF	SGN	BT	DTN
3	-	-	0.00	-	-	-	-	-	-
5	0.08	0.08	0.00	1.50	0.00	-	-	-	-
6	-	-	0.00	0.07	0.00	-	0.00	-	-
7	0.00	0.00	0.00	0.00	0.00	-	0.00	-	-
8	0.00	0.00	0.00	0.07	0.00	-	0.63	-	-
9	0.67	0.00	0.80	0.54	0.20	-	-	-	-
10	0.00	0.33	0.13	0.33	0.00	-	-	-	-
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-
14	0.00	0.17	0.00	0.24	0.00	0.03	0.08	-	-
15	0.33	0.33	0.30	0.08	0.00	0.00	0.00	-	-
17	-	-	-	-	-	0.00	0.00	-	0.00
18	0.00	0.00	-	-	-	0.04	0.07	2.67	0.00
19	22.67	-	0.50	-	-	0.04	0.00	-	0.00
21	0.00	0.00	-	-	-	0.05	0.08	2.50	0.17
22	-	-	8.50	0.28	0.00	0.10	0.17	4.67	0.17
23	0.53	0.10	7.67	0.00	0.50	0.04	0.07	15.33	0.00
25	0.83	0.00	8.50	0.00	0.00	0.03	0.00	1.33	0.00
27	0.00	0.00	0.50	0.08	0.75	0.04	0.00	-	-

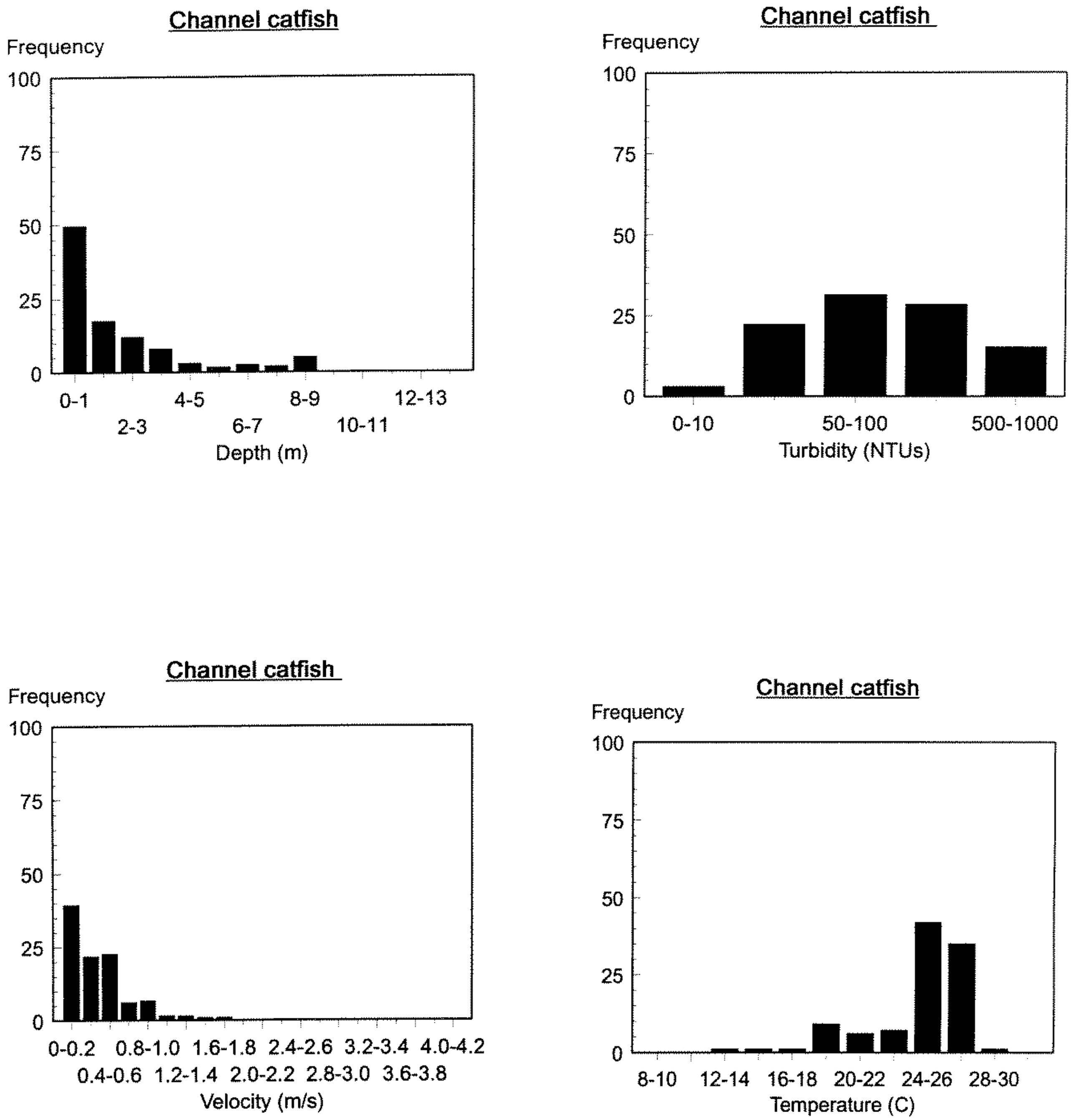


Figure 63. Frequency of occurrence of channel catfish (N=985) in various depth, velocity, turbidity, and water temperature intervals from Missouri and Lower Yellowstone River collections in 1996.

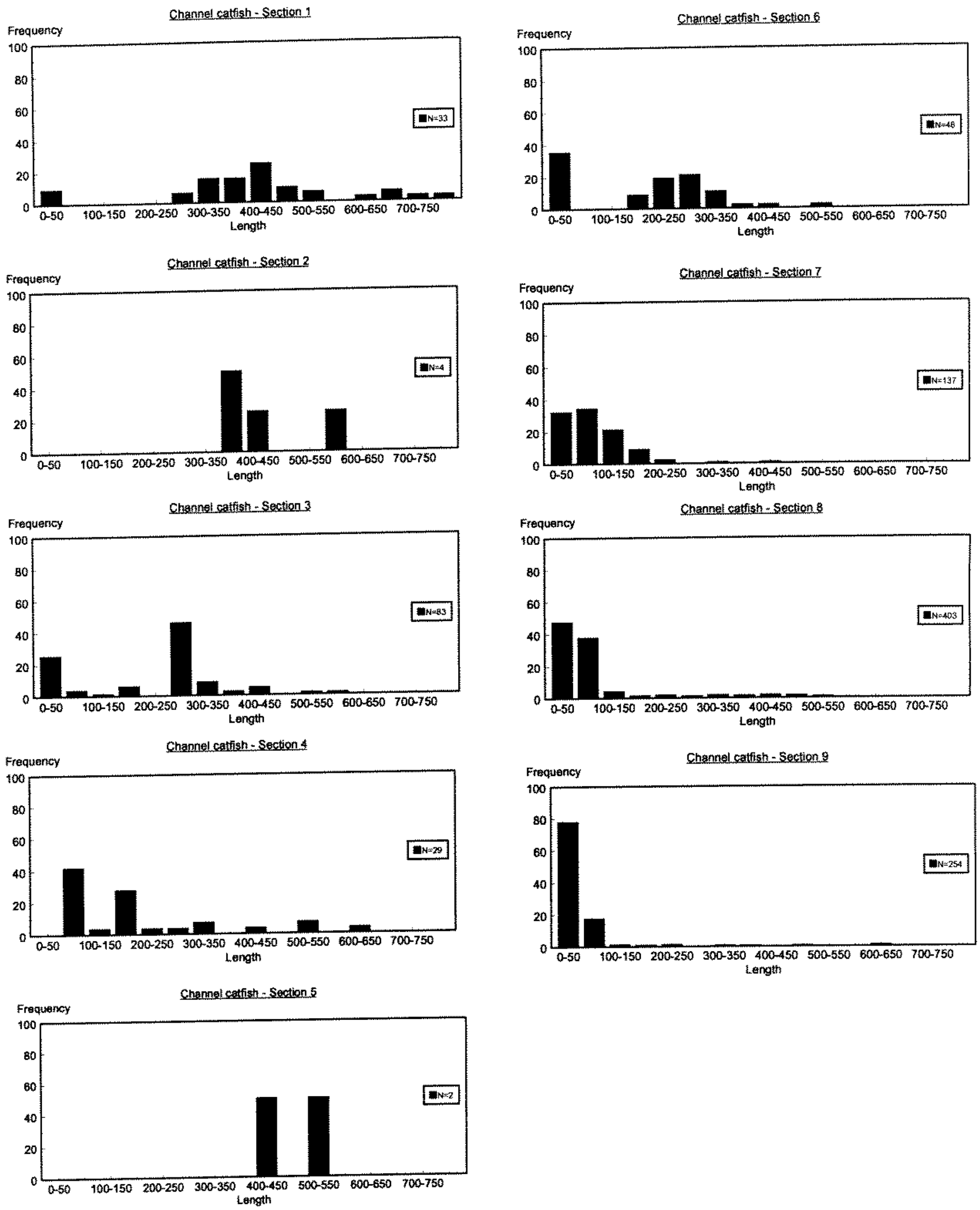


Figure 64. Length-frequency histograms of channel catfish collected in Missouri River study sections during 1996 by drifting trammel nets, experimental gill nets, a benthic trawl, bag seine, and boat electrofishing.

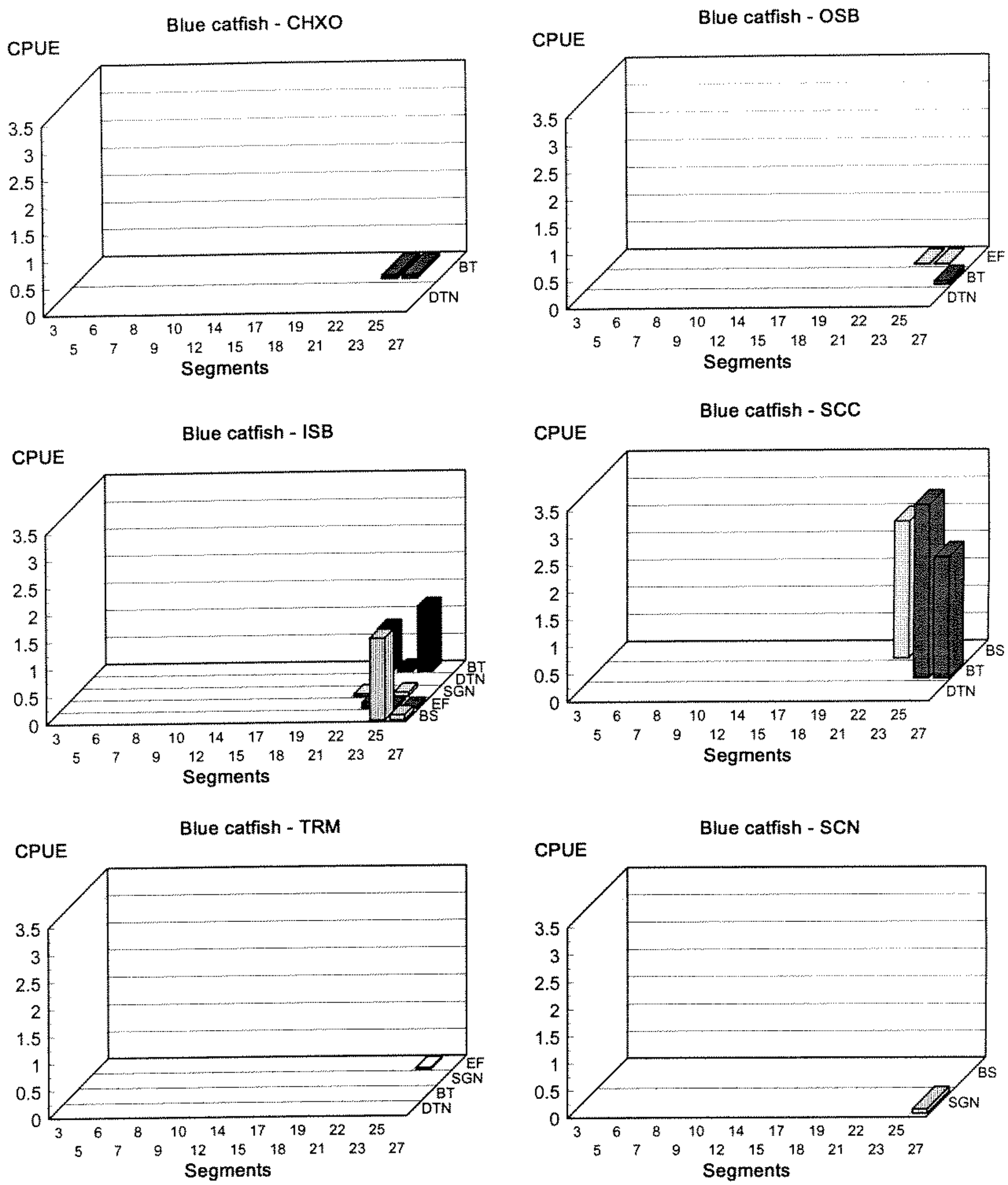


Figure 65. Trends of blue catfish catch rates among Missouri River study segments and macrohabitats in 1996. Catch rates for a benthic trawl (BT) and drifting trammel net (DTN) are #/100 m, for a bag seine (BS) - #/180 degree haul, experimental gill net (SGN) - #/hr, and electrofishing (EF) - #/min. See Appendix A for macrohabitat acronyms.

Table 45. Relative abundance of blue catfish collected in 18 Missouri River study segments in continuous macrohabitats (channel crossover-CHXO; outside bend-OSB; and inside bend-ISB) during 1996. Relative abundance in the various gears are #/100 m in drifting trammel nets (DTN) and a benthic trawl (BT); #/hr in stationary gill nets (SGN); #/min with boat electrofishing (EF); and #/180 degree shoreline haul with a bag seine (BS). A "-" indicates not sampled.

	CHXO			OSB				ISB		
Segment	BT	DTN	EF	BT	DTN	BS	SGN	EF	BT	DTN
3	-	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
6	0.00	0.00	-	-	-	0.00	-	-	-	-
7	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
9	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
12	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
15	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
18	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
21	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	0.05	0.00	0.80	0.00
23	0.07	0.00	0.01	0.00	0.00	0.00	0.00	0.11	0.07	0.00
25	0.07	0.00	0.01	0.00	0.00	1.50	0.07	0.04	1.20	0.00
27	0.00	0.00	0.00	0.07	0.00	0.10	0.00	0.03	0.00	0.00

Table 46. Relative abundance of blue catfish collected in 18 Missouri River study segments in discrete macrohabitats (secondary channels connected-SCC; secondary channels non-connected-SCN; tributary mouths-TRM) during 1996. Relative abundance in the various gears are #/100 m in drifting trammel nets (DTN) and a benthic trawl (BT); #/hr in stationary gill nets (SGN); #/min with boat electrofishing (EF); and #/180 degree shoreline haul with a bag seine (BS). A "-" indicates not sampled.

	SCC			SCN		TRM			
Segment	BT	DTN	BS	SGN	BS	EF	SGN	BT	DTN
3	-	-	0.00	-	-	-	-	-	-
5	0.00	0.00	0.00	0.00	0.00	-	-	-	-
6	-	-	0.00	0.00	0.00	-	0.00	-	-
7	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	-	-
9	0.00	0.00	0.00	0.00	0.00	-	-	-	-
10	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	-	-
14	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	-	-
17	-	-	-	-	-	0.00	0.00	-	0.00
18	0.00	0.00	-	-	-	0.00	0.00	0.00	0.00
19	0.00	-	0.00	-	-	0.00	0.00	-	0.00
21	0.00	0.00	-	-	-	0.00	0.00	0.00	0.00
22	-	-	2.50	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
25	3.17	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00
27	2.21	0.00	0.00	0.08	0.00	0.00	0.00	-	-

SCC-DEEP, CHXOs, and OSBs. Blue catfish were only captured in TRM-SMLL (i.e., Big Bonne Femme Creek, MO) by electrofishing in segment *25*. Also, they were only collected in one SCN (i.e., Bryan Island Chute, MO, rmi 26-22) in a stationary gill net in segment *27*.

Most blue catfish were captured in shallow to moderate depths (0-5 m) and slow to moderate velocities (0-1.0 m/s) (Figure 66). About 75% of blue catfish were collected in velocities < 0.6 m/s. Also, they were collected in turbid (about 85% in turbidities > 100 NTUs), warm waters (100% of individuals collected in temperatures > 24 °C), likely a result of all collections in the most downstream segments.

Most blue catfish collected in sections *8* and *9* were < 100 mm long, which were likely juveniles (Pflieger 1975; Harlan and Speaker 1987) (Figure 67). Twenty-three blue catfish were collected in section *8* with 55% between 50 and 100 mm and 35% < 50 mm. The largest specimen (650 mm) was collected in section *9*. Eighty blue catfish were collected in section *9* with 70% < 50 mm and 25% between 50 and 100 mm suggesting good reproduction in 1996 and good recruitment to our gear.

Stonecat (STCT)

Stonecat were scarce (i.e., only 44 collected) in 1996 collections. They were not captured downstream of segment *17* (i.e., downstream of rmi 669.0) (Figure 68; Tables 47 and 48). Most (59%) were collected in least-impacted segments 3, 5, and 9, followed by 39% in inter-reservoir segments **10, 14,** and **15**. Only one individual was collected in a channelized segment (*17*). They were collected with bag seines, benthic trawls, and electrofishing in CHXOs, OSBs, ISB-CHNBs, ISB-BARS, ISB-STPS, SCC-SHLW, SCC-DEEP, and WILD macro- and meso-habitats. Bag seine catch rates in the WILD macrohabitat (i.e., Niobrara River mouth in segment **14**) were 0.5/haul. They were not collected in TRMs and SCN.

Stonecat were found in depths ranging from 0 to 8 m with most (45%) in depths from 2 to 3 m (Figure 69). Stonecat were collected in velocities ranging from 0.0 to 1.4 m/s with the largest percentage (30%) in 0.6 to 0.8 m/s. Remaining stonecat collections were almost equally distributed around 0.6 to 0.8 m/s in a bell curve from 0 to 0.6 m/s and 0.8 to 1.4 m/s.

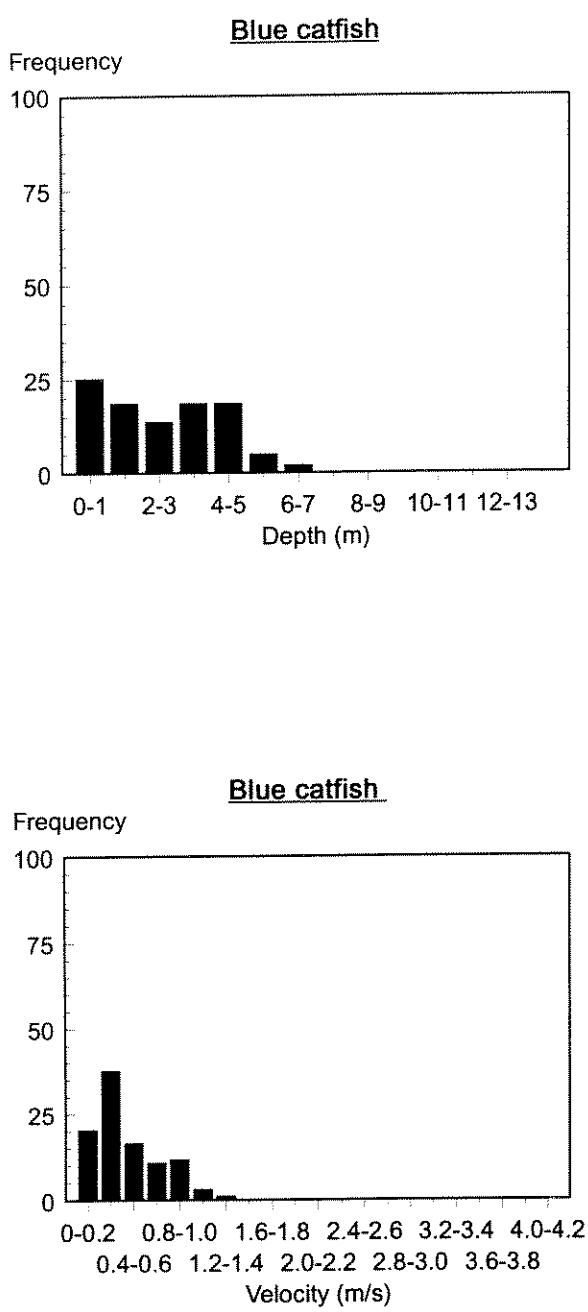


Figure 66. Frequency of occurrence of blue catfish (N=103) in various depth, velocity, turbidity, and water temperature intervals from Missouri and Lower Yellowstone River collections in 1996.

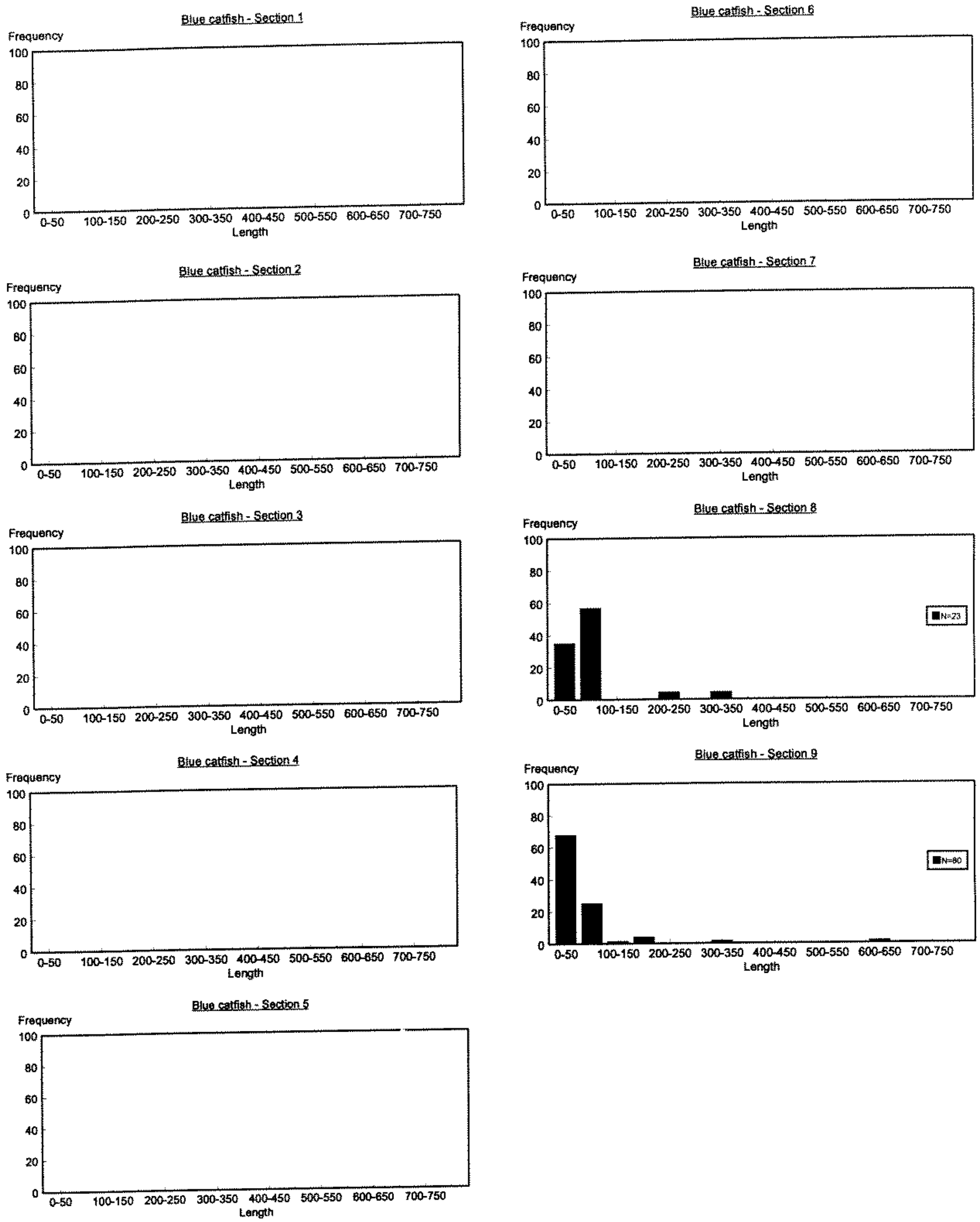


Figure 67. Length-frequency histograms of blue catfish collected in Missouri River study sections during 1996 by drifting trammel nets, experimental gill nets, a benthic trawl, bag seine, and by boat electrofishing.

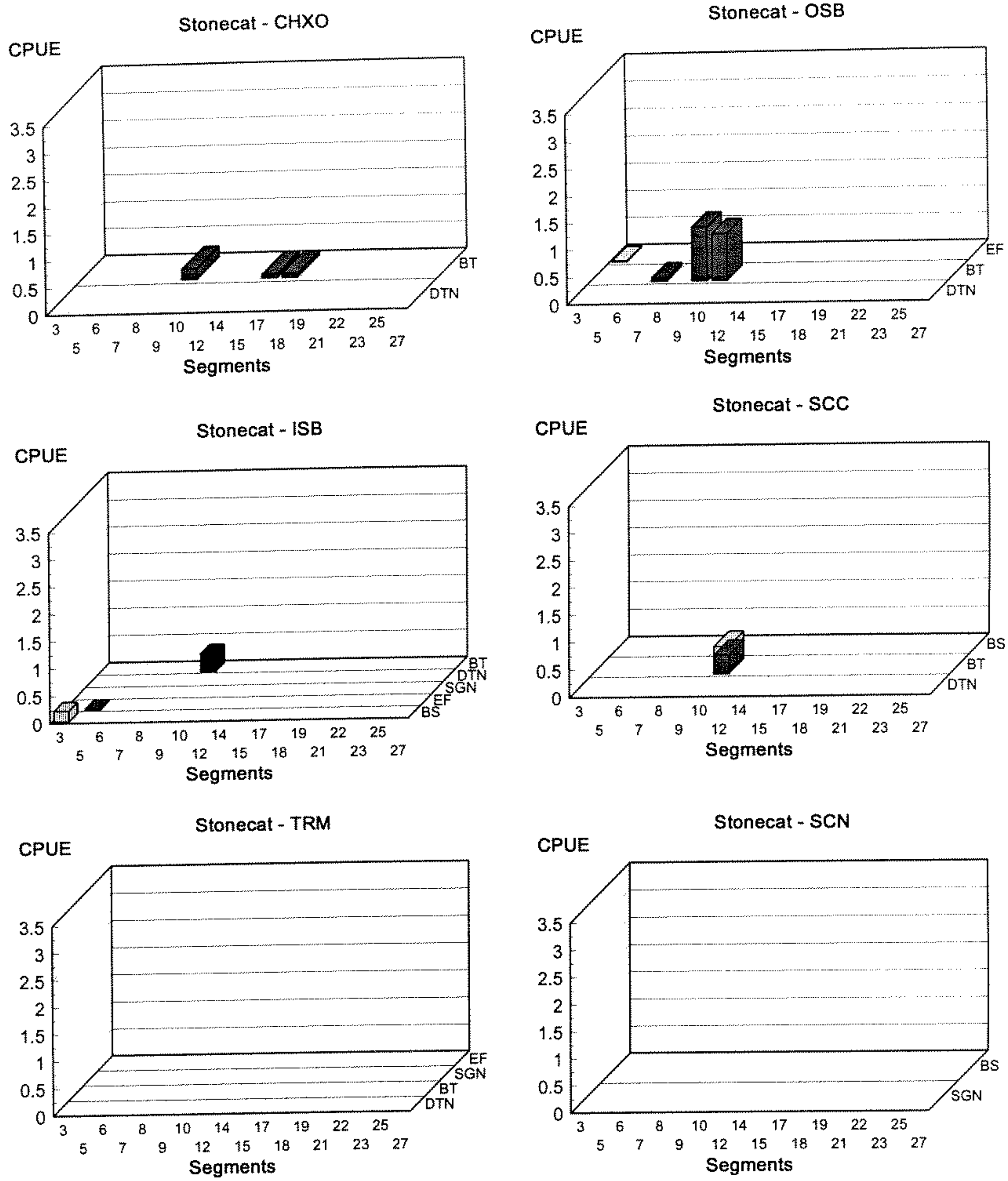


Figure 68. Trends in stonecat catch rates among Missouri River study segments and macrohabitats in 1996. Catch rates for a benthic trawl (BT) and drifting trammel net (DTN) are #/100 m, for a bag seine (BS) - #/180 degree haul, experimental gill net (SGN) - #/hr, and electrofishing (EF) - #/min. See Appendix A for macrohabitat acronyms.

Table 47. Relative abundance of stonecat collected in 18 Missouri River study segments in continuous macrohabitats (channel crossover-CHXO; outside bend-OSB; and inside bend-ISB) during 1996. Relative abundance in the various gears are #/100 m in drifting trammel nets (DTN) and a benthic trawl (BT); #/hr in stationary gill nets (SGN); #/min with boat electrofishing (EF); and #/180 degree shoreline haul with a bag seine (BS). A "-" indicates not sampled.

	CHXO		OSB			ISB				
Segment	BT	DTN	EF	BT	DTN	BS	SGN	EF	BT	DTN
3	-	0.00	0.00	-	0.00	0.20	-	-	-	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	-	0.01	0.00	0.00
6	0.00	0.00	-	-	-	0.00	-	-	-	-
7	0.00	0.00	-	0.07	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
9	0.20	0.00	-	0.99	0.00	0.00	0.00	-	0.33	0.00
10	0.00	0.00	0.00	0.87	0.00	0.00	-	-	0.00	0.00
12	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
15	0.07	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00
17	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	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
21	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
23	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
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 48. Relative abundance of stonecat collected in 18 Missouri River study segments in discrete macrohabitats (secondary channels connected-SCC; secondary channels non-connected-SCN; tributary mouths-TRM) during 1996. Relative abundance in the various gears are #/100 m in drifting trammel nets (DTN) and a benthic trawl (BT); #/hr in stationary gill nets (SGN); #/min with boat electrofishing (EF); and #/180 degree shoreline haul with a bag seine (BS). A "-" indicates not sampled.

	SCC			SCN		TRM			
Segment	BT	DTN	BS	SGN	BS	EF	SGN	BT	DTN
3	-	-	0.00	-	-	-	-	-	-
5	0.00	0.00	0.00	0.00	0.00	-	-	-	-
6	-	-	0.00	0.00	0.00	-	0.00	-	-
7	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	-	-
9	0.00	0.00	0.10	0.00	0.00	-	-	-	-
10	0.33	0.00	0.00	0.00	0.00	-	-	-	-
12	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	-	-
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-
17	-	-	-	-	-	0.00	0.00	-	0.00
18	0.00	0.00	-	-	-	0.00	0.00	0.00	0.00
19	0.00	-	0.00	-	-	0.00	0.00	-	0.00
21	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
23	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
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-

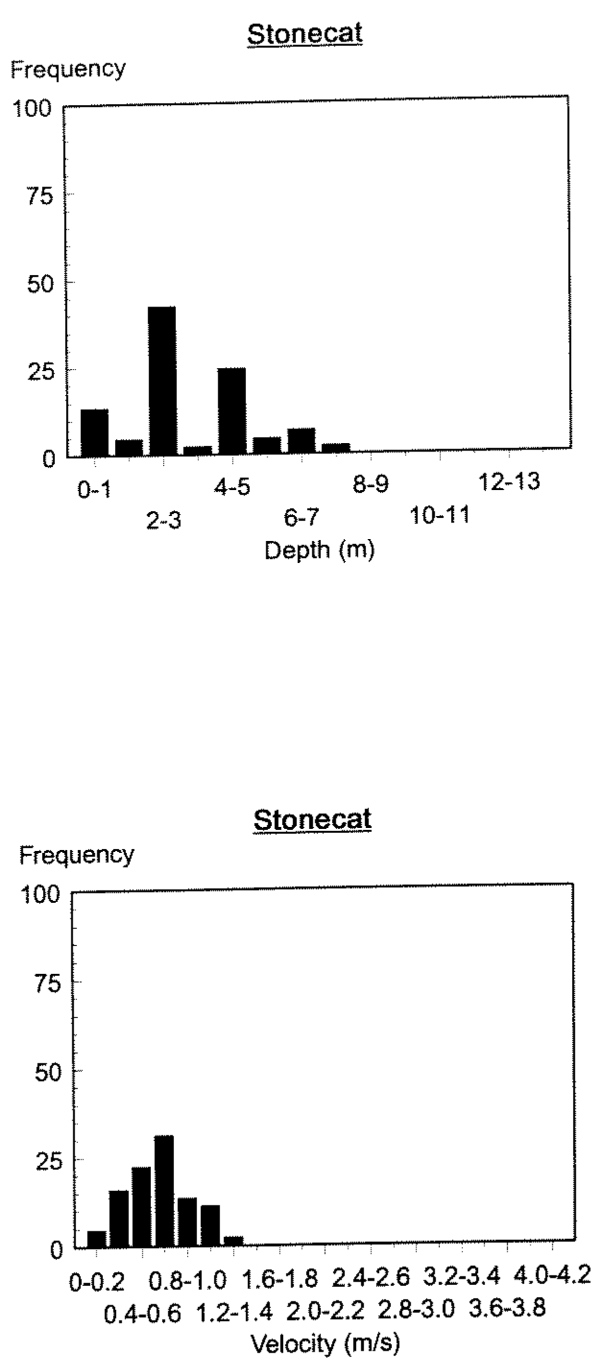


Figure 69. Frequency of occurrence of stonecat (N=44) in various depth, velocity, turbidity, and water temperature intervals from Missouri and Lower Yellowstone River collections in 1996.

Most stonecat were found in turbidities < 100 NTUs. Stonecat were generally collected in warmer waters (96% in temperatures warmer than 18 °C). One individual was collected in 10-12 °C.

Stonecat lengths varied from 15 to 197 mm with most < 150 mm (Figure 70). Stonecat lengths exceeded 150 mm only in sections 1 and **4**. Stonecat < 50 mm (possibly indicating natural reproduction, Pflieger 1975) were only found in sections 1 and 3.

Flathead catfish (FHCF)

Five-hundred-thirty-five flathead catfish were collected predominantly from channelized segments with all gears except the bag seine (Figure 71; Tables 49 and 50). Six percent of the flathead catfish were collected in segment **15**, an inter-reservoir segment. They were found in all macro- and meso-habitats except secondary channels (i.e., SCC and SCN). Most were collected in OSBs and TRMs. Few flathead catfish were captured with the benthic trawl and drifting trammel nets. Conversely, electrofishing was an effective gear for collecting this species. In order from greatest frequency of occurance with this gear, they were captured in OSBs, TRM-SMLL, and ISB-STPSs. They were also collected by electrofishing ISB-BARS and SCN, both non-standardized procedures and not reported in Tables 49 and 50. Catch rates in ISB-BARS in segments *17*, *18*, and *19* were 0.20, 0.20, and 0.50/min, respectively. Catch rates in a SCN (i.e., Centaur Chute, MO, rmi 45) in segment *27* were 0.06/min. Gill nets collected flathead catfish only in TRM-SMLL.

Flathead catfish were predominately captured in shallow depths (75% in depths < 2 m) and a wide range of velocities (0.0-1.8 m/s) and turbidities (10-1000 NTUs) (Figure 72). Nearly 75% were in velocities from 0.0 to 0.6 m/s. They were not collected in turbidities < 10 NTUs. All flathead catfish were collected in warm waters (> 18 °C), with most (72%) in temperatures between 24 and 26 °C.

Flathead catfish length frequencies in sections **6**, *7*, *8*, and *9* ranged from 0 to 750 mm (Figure 73). Most fish were < 200 mm with declining distributions as lengths increased. Even with the number of small fish, flathead catfish < 50 mm were only found in sections *8* and *9*.

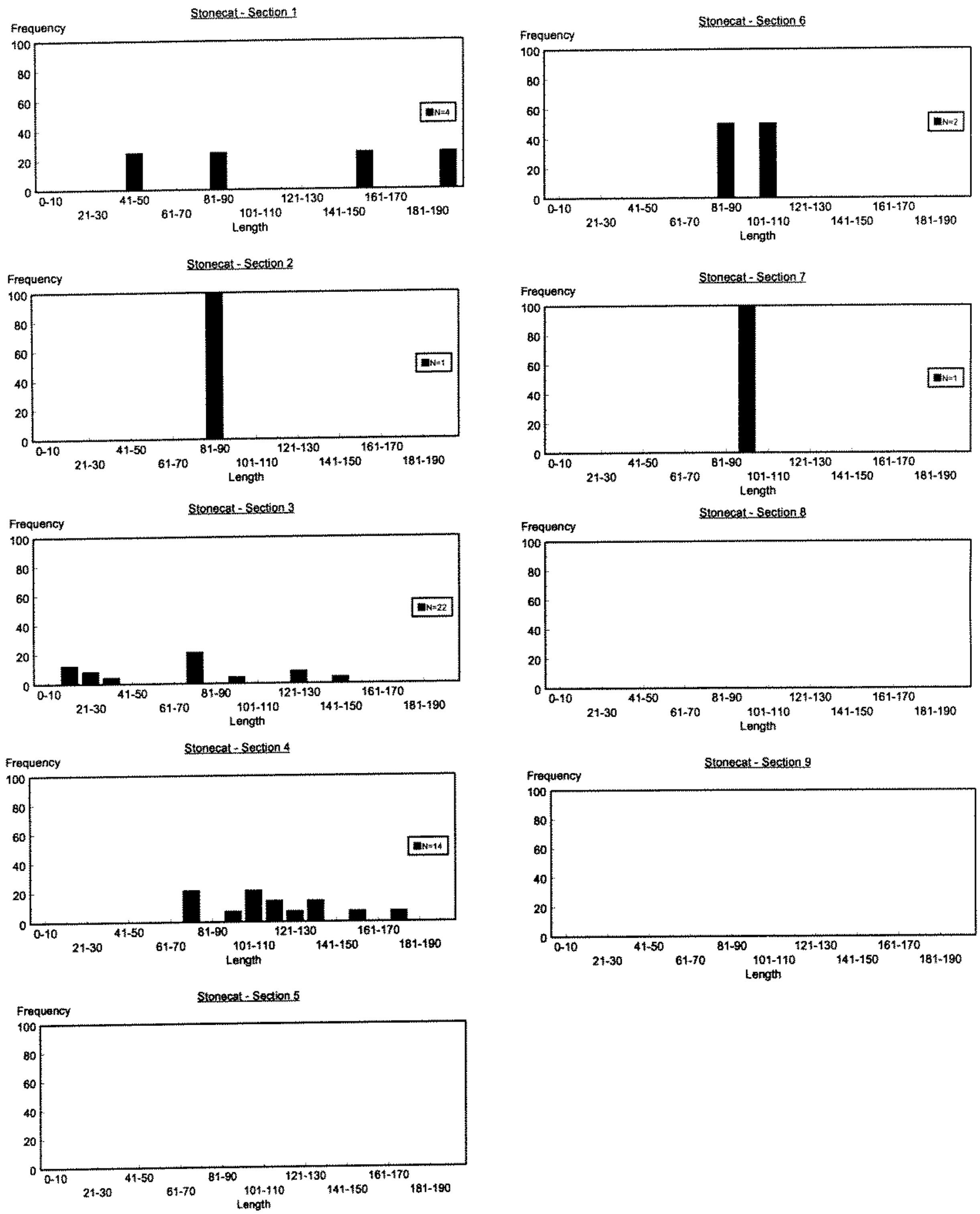


Figure 70. Length-frequency histograms of stonecat collected in Missouri River study sections during 1996 by drifting trammel nets, experimental gill nets, a benthic trawl, bag seine, and by boat electrofishing.

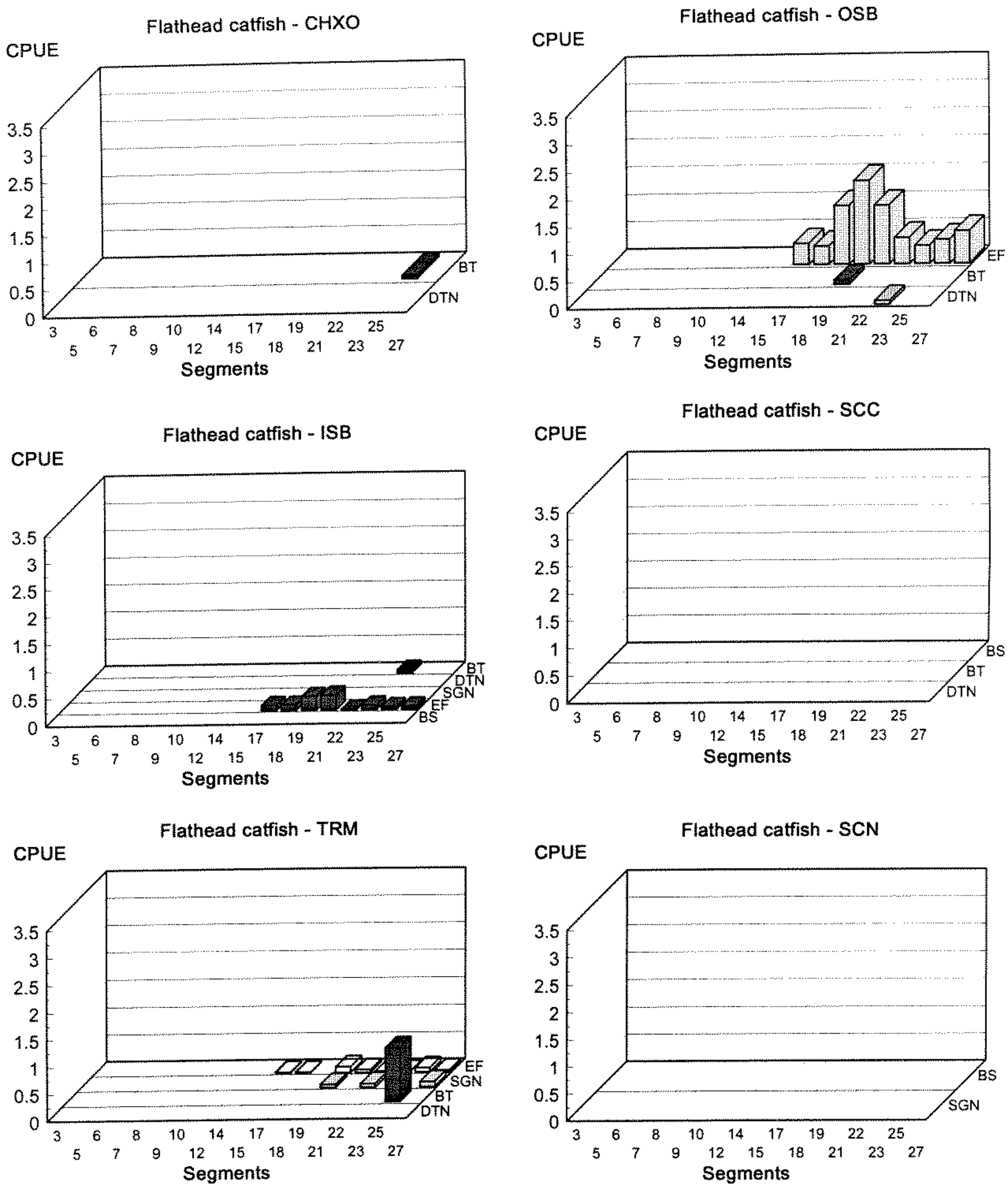


Figure 71. Trends in flathead catfish catch rates among Missouri River study segments and macrohabitats in 1996. Catch rates for a benthic trawl (BT) and drifting trammel net (DTN) are #/100 m, for a bag seine (BS) - #/180 degree haul, experimental gill net (SGN) - #/hr, and electrofishing (EF) - #/min. See Appendix A for macrohabitat acronyms.

Table 49. Relative abundance of flathead catfish collected in 18 Missouri River study segments in continuous macrohabitats (channel crossover-CHXO; outside bend-OSB; and inside bend-ISB) during 1996. Relative abundance in the various gears are #/100 m in drifting trammel nets (DTN) and a benthic trawl (BT); #/hr in stationary gill nets (SGN); #/min with boat electrofishing (EF); and #/180 degree shoreline haul with a bag seine (BS). A "-" indicates not sampled.

	CHXO		OSB			ISB				
Segment	BT	DTN	EF	BT	DTN	BS	SGN	EF	BT	DTN
3	-	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
6	0.00	0.00	-	-	-	0.00	-	-	-	-
7	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
9	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
12	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
15	0.00	0.00	0.38	0.00	0.00	0.00	-	-	0.00	0.00
17	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.10	0.00	0.00
18	0.00	0.00	1.07	0.00	0.00	-	0.00	0.10	0.00	0.00
19	0.00	0.00	1.52	0.08	0.00	-	0.00	0.25	0.00	0.00
21	0.00	0.00	1.07	0.00	0.00	0.00	0.00	0.27	0.00	0.00
22	0.00	0.00	0.48	0.00	0.00	0.00	0.00	0.01	0.00	0.00
23	0.00	0.00	0.33	0.00	0.07	0.00	0.00	0.08	0.07	0.00
25	0.07	0.00	0.44	0.00	0.00	0.00	0.00	0.05	0.00	0.00
27	0.00	0.00	0.60	0.00	0.00	0.00	0.00	0.06	0.00	0.00

Table 50. Relative abundance of flathead catfish collected in 18 Missouri River study segments in discrete macrohabitats (secondary channels connected-SCC; secondary channels non-connected-SCN; tributary mouths-TRM) during 1996. Relative abundance in the various gears are #/100 m in drifting trammel nets (DTN) and a benthic trawl (BT); #/hr in stationary gill nets (SGN); #/min with boat electrofishing (EF); and #/180 degree shoreline haul with a bag seine (BS). A "-" indicates not sampled.

	SCC			SCN		TRM			
Segment	BT	DTN	BS	SGN	BS	EF	SGN	BT	DTN
3	-	-	0.00	-	-	-	-	-	-
5	0.00	0.00	0.00	0.00	0.00	-	-	-	-
6	-	-	0.00	0.00	0.00	-	0.00	-	-
7	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	-	-
9	0.00	0.00	0.00	0.00	0.00	-	-	-	-
10	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	-	-
14	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	0.01	0.00	-	-
17	-	-	-	-	-	0.01	0.00	-	0.00
18	0.00	0.00	-	-	-	0.00	0.00	0.00	0.00
19	0.00	-	0.00	-	-	0.11	0.06	-	0.00
21	0.00	0.00	-	-	-	0.05	0.00	0.00	0.00
22	-	-	0.00	0.00	0.00	0.03	0.07	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
25	0.00	0.00	0.00	0.00	0.00	0.08	0.00	1.00	0.00
27	0.00	0.00	0.00	0.00	0.00	0.03	0.10	-	-

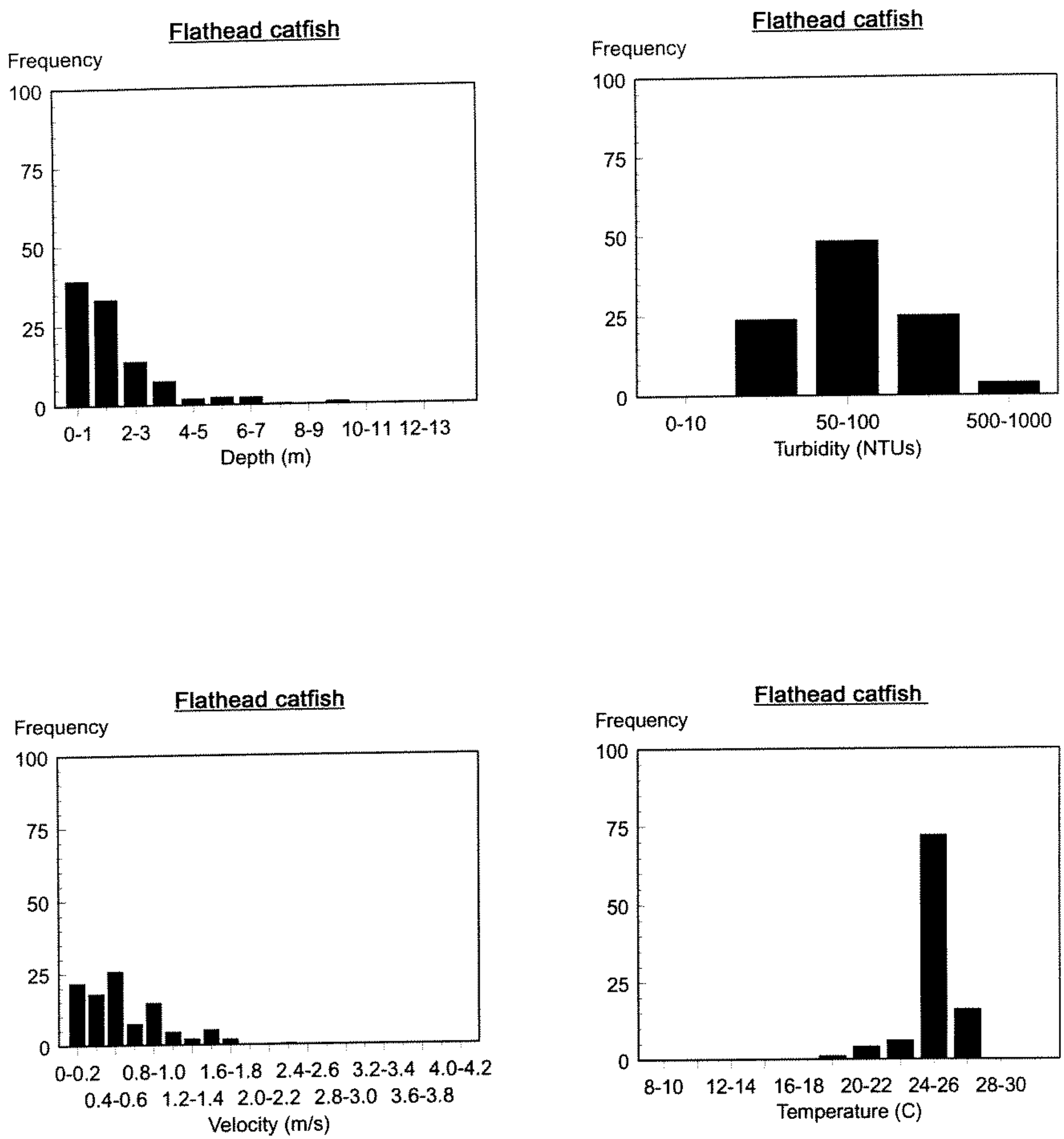


Figure 72. Frequency of occurrence of flathead catfish (N=535) in various depth, velocity, turbidity, and water temperature intervals from Missouri and Lower Yellowstone River collections in 1996.

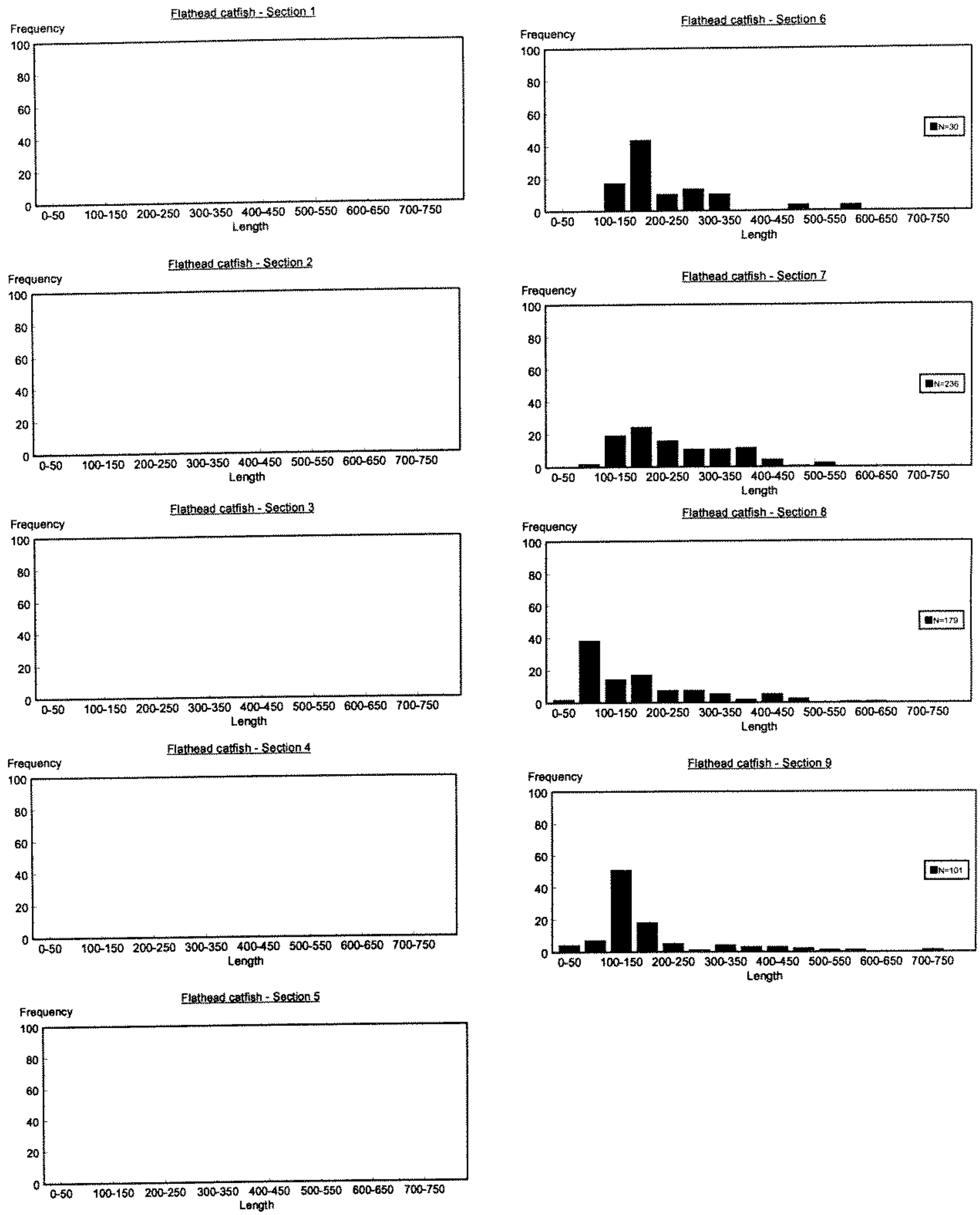


Figure 73. Length-frequency histograms of flathead catfish collected in Missouri River study sections during 1996 by drifting trammel nets, experimental gill nets, a benthic trawl, bag seine, and boat electrofishing.

Burbot (BRBT)

Like bigmouth buffalo and stonecat, burbot were scarce (i.e., only 65 collected) in 1996 collections. They were only collected in least-impacted (3, 5) and inter-reservoir segments (**7, 8, 10**) with all gears except gill nets (Figure 74; Tables 51 and 52). Catch was equally split between least-impacted and inter-reservoir segments. They were not collected downstream of rmi 1552 (i.e., downstream of Lake Sakakawea headwaters, North Dakota). Also, no burbot were captured in TRM and SCN macrohabitats.

Burbot were generally found in shallow depths (70% in depths from 1 to 2 m) and slow velocities (80% in velocities from 0.2 to 0.4 m/s) (Figure 75). Most were collected in moderate turbidities and cool waters (i.e., about 80% collected in tubidities from 10-100 NTUs and water temperatures between 16 and 22 °C).

Most burbot captured were < 250 mm with the greatest distribution in section 1 (Figure 76). Burbot lengths in section 1 varied between 0-50 and 700-750 mm length intervals and in section **4** between 0-50 and 300-350 mm length intervals. Only three specimens were captured in section **2** with a range of 100 to 600 mm.

Walleye (WLYE)

Walleye were collected throughout the river in 1996, but in low numbers (i.e., 52 collected). Most were collected in inter-reservoir segments (78% in segments **6, 8, 12, 14, 15**) in TRMs and SCN (Figure 77; Tables 53 and 54). Twelve percent were collected in least-impacted segments (5 and 9) in OSBs, ISBs, and SCC. Only 10% were collected in channelized segments (*17, 18, 19, 21, 23,* and *25*). They were collected in a WILD macrohabitat (i.e., Garrison Dam tailrace) by drifting trammel nets. No walleye were collected in CHXOs.

Walleye were predominatly found in shallow depths (75% in depths < 2 m), slow velocities (80% in velocities < 0.2 m/s), and clear waters (90% in turbidities < 50 NTUs) (Figure 78). They were collected in a wide range of water temperatures (i.e., 10-28 °C) with most (66%) in temperatures between 20 and 24 °C.

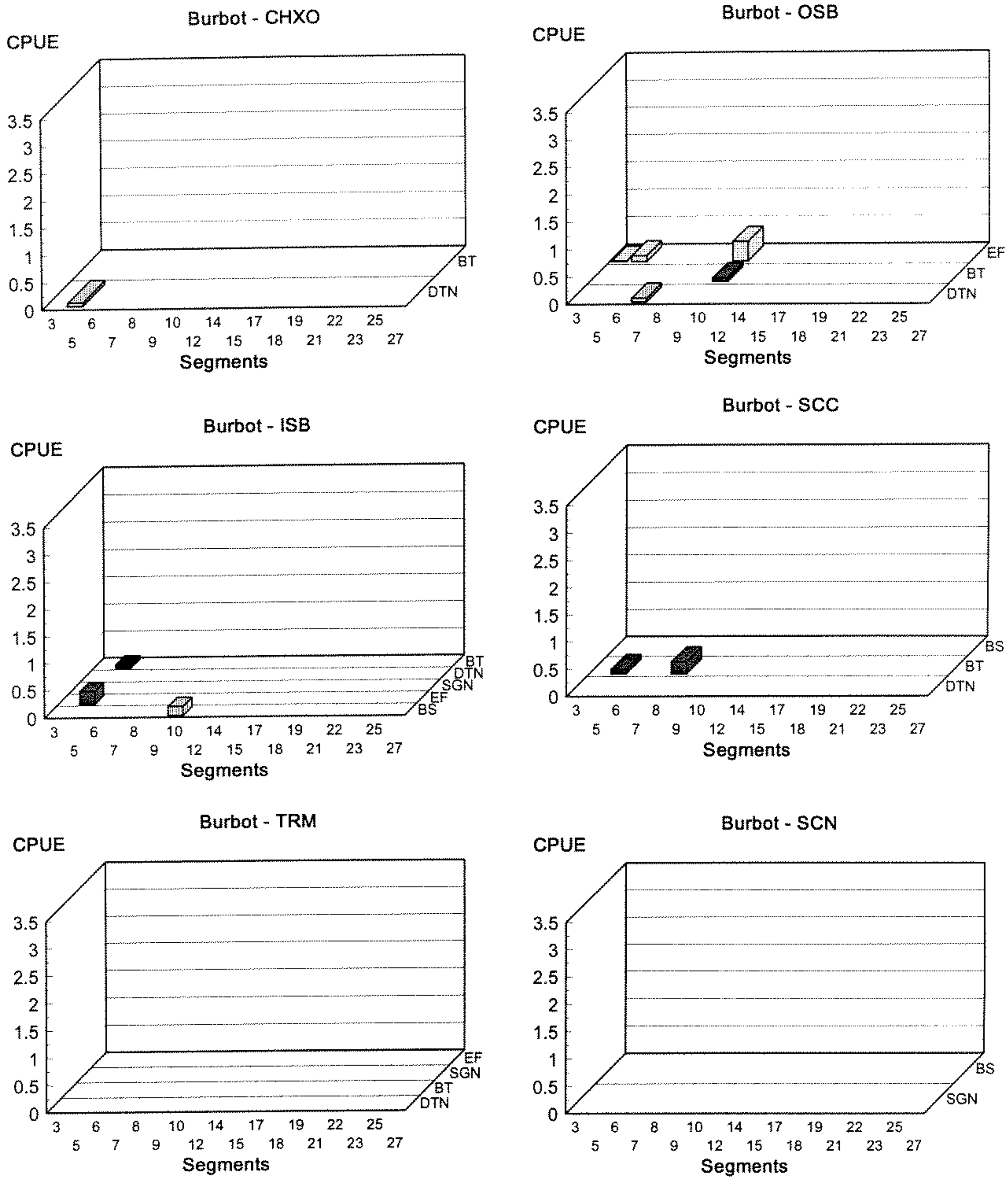


Figure 74. Trends in burbot catch rates among Missouri River study segments and macrohabitats in 1996. Catch rates for a benthic trawl (BT) and drifting trammel net (DTN) are #/100 m, for a bag seine (BS) - #/180 degree haul, experimental gill net (SGN) - #/hr, and electrofishing (EF) - #/min. See Appendix A for macrohabitat acronyms.

Table 51. Relative abundance of burbot collected in 18 Missouri River study segments in continuous macrohabitats (channel crossover-CHXO; outside bend-OSB; and inside bend-ISB) during 1996. Relative abundance in the various gears are #/100 m in drifting trammel nets (DTN) and a benthic trawl (BT); #/hr in stationary gill nets (SGN); #/min with boat electrofishing (EF); and #/180 degree shoreline haul with a bag seine (BS). A "-" indicates not sampled.

	CHXO		OSB			ISB				
Segment	BT	DTN	EF	BT	DTN	BS	SGN	EF	BT	DTN
3	-	0.00	0.00	-	0.00	0.00	-	-	-	0.00
5	0.00	0.07	0.11	0.00	0.00	0.00	-	0.24	0.07	0.00
6	0.00	0.00	-	-	-	0.00	-	-	-	-
7	0.00	0.00	-	0.00	0.07	0.00	-	-	0.00	0.00
8	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
10	0.00	0.00	0.36	0.07	0.00	0.17	-	-	0.00	0.00
12	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
15	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
18	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
21	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
23	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
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 52. Relative abundance of burbot collected in 18 Missouri River study segments in discrete macrohabitats (secondary channels connected-SCC; secondary channels non-connected-SCN; tributary mouths-TRM) during 1996. Relative abundance in the various gears are #/100 m in drifting trammel nets (DTN) and a benthic trawl (BT); #/hr in stationary gill nets (SGN); #/min with boat electrofishing (EF); and #/180 degree shoreline haul with a bag seine (BS). A "-" indicates not sampled.

	SCC			SCN		TRM			
Segment	BT	DTN	BS	SGN	BS	EF	SGN	BT	DTN
3	-	-	0.00	-	-	-	-	-	-
5	0.08	0.00	0.00	0.00	0.00	-	-	-	-
6	-	-	0.00	0.00	0.00	-	0.00	-	-
7	0.00	0.00	0.00	0.00	0.00	-	0.00	-	-
8	0.22	0.00	0.00	0.00	0.00	-	0.00	-	-
9	0.00	0.00	0.00	0.00	0.00	-	-	-	-
10	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	-	-
14	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	-	-
17	-	-	-	-	-	0.00	0.00	-	0.00
18	0.00	0.00	-	-	-	0.00	0.00	0.00	0.00
19	0.00	-	0.00	-	-	0.00	0.00	-	0.00
21	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
23	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
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-

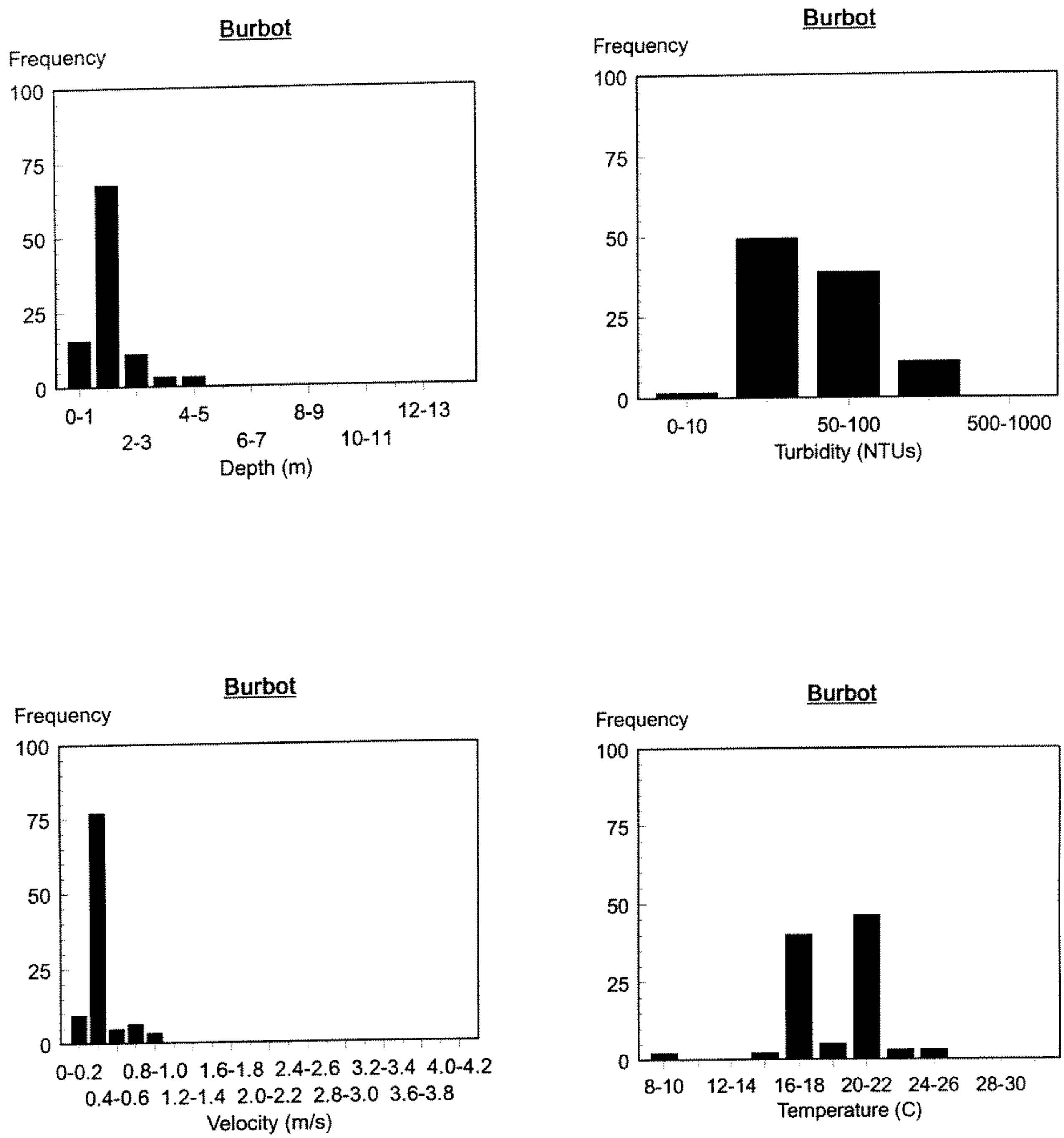


Figure 75. Frequency of occurrence of burbot (N=63) in various depth, velocity, turbidity, and water temperature intervals from Missouri and Lower Yellowstone River collections in 1996.

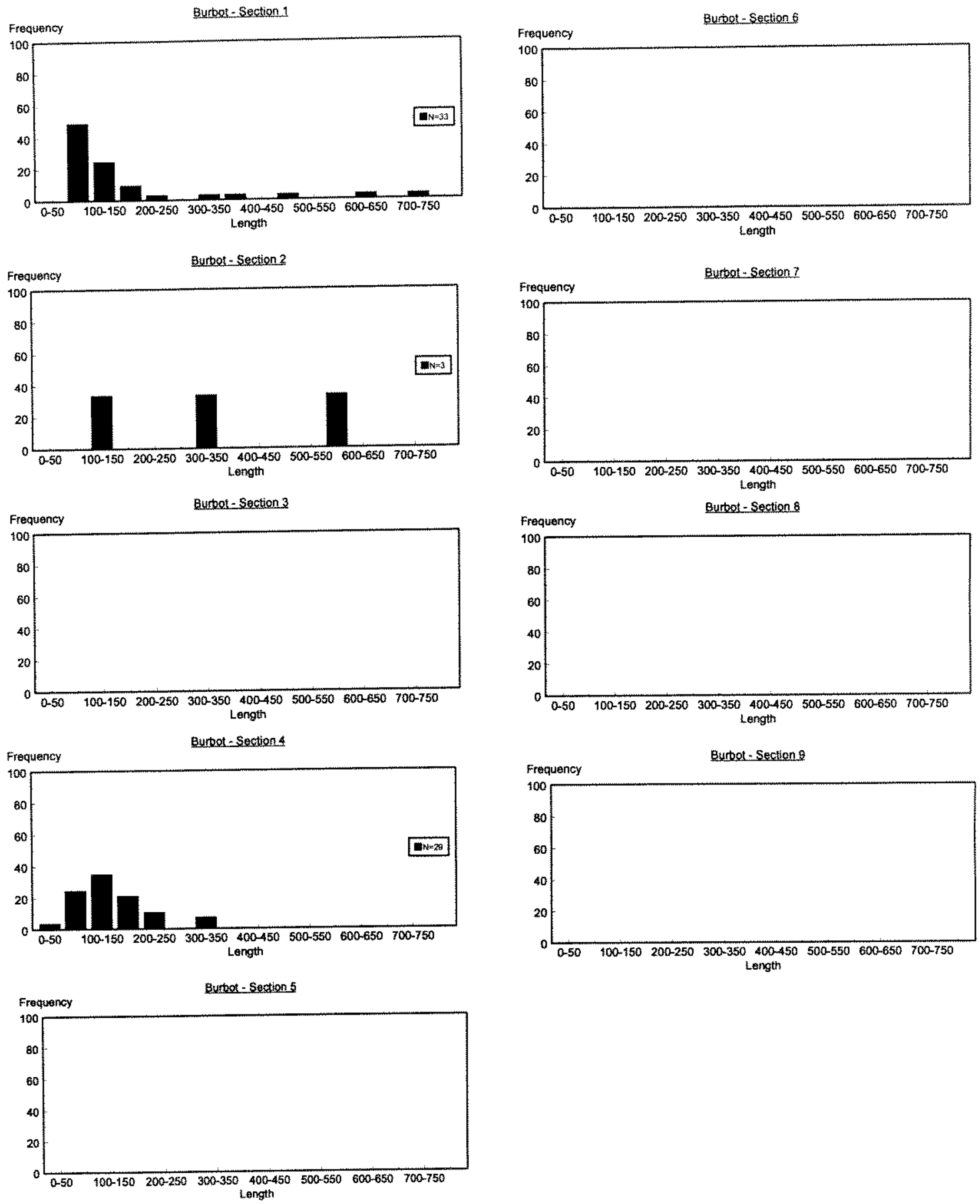


Figure 76. Length-frequency histograms of burbot collected in Missouri River study sections during 1996 by drifting trammel nets, experimental gill nets, a benthic trawl, bag seine, and by boat electrofishing.

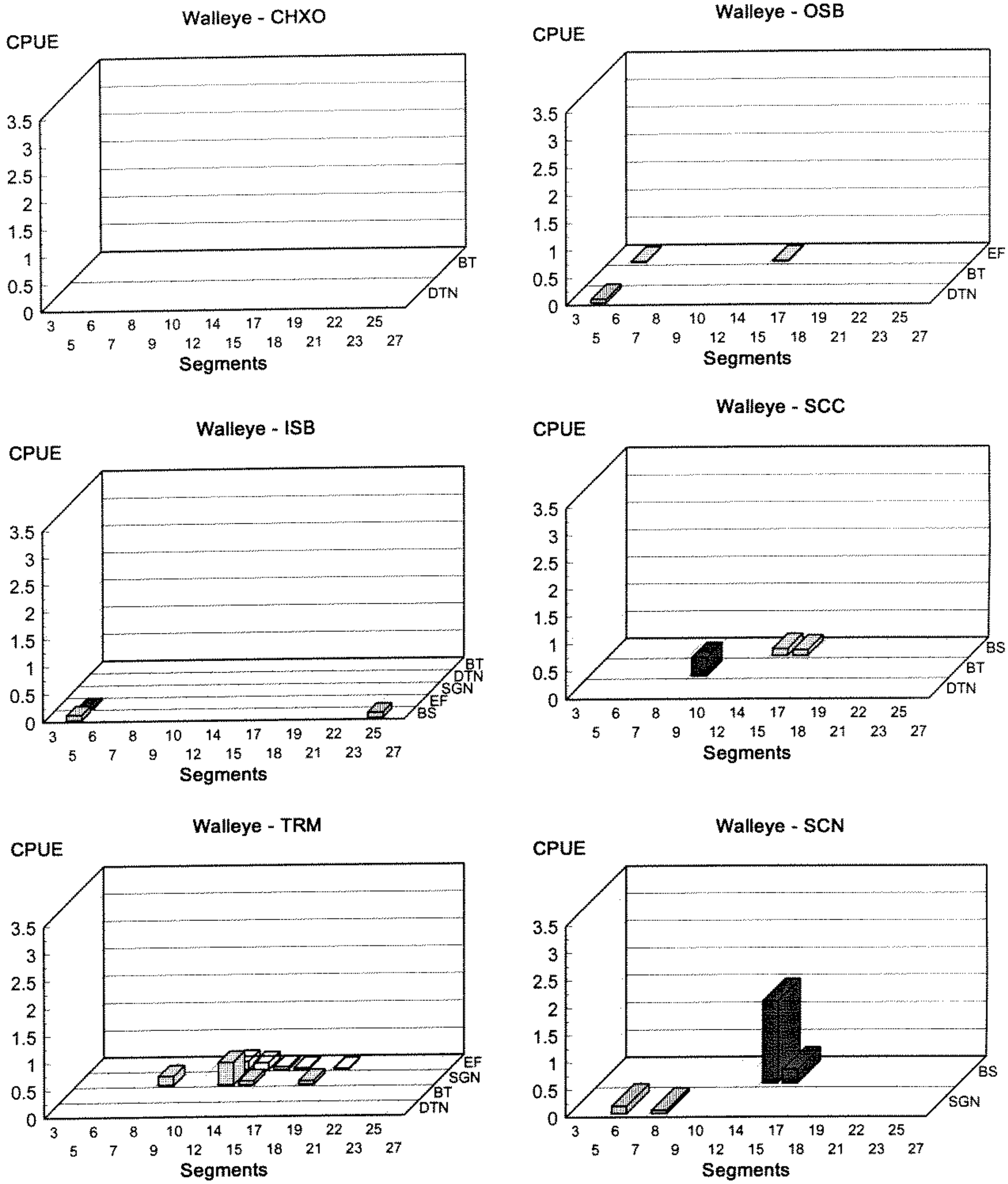


Figure 77. Trends in walleye catch rates among Missouri River study segments and macrohabitats in 1996. Catch rates for a benthic trawl (BT) and drifting trammel net (DTN) are #/100 m, for a bag seine (BS) - #/180 degree haul, experimental gill net (SGN) - #/hr, and electrofishing (EF) - #/min. See Appendix A for macrohabitat acronyms.

Table 53. Relative abundance of walleye collected in 18 Missouri River study segments in continuous macrohabitats (channel crossover-CHXO; outside bend-OSB; and inside bend-ISB) during 1996. Relative abundance in the various gears are #/100 m in drifting trammel nets (DTN) and a benthic trawl (BT); #/hr in stationary gill nets (SGN); #/min with boat electrofishing (EF); and #/180 degree shoreline haul with a bag seine (BS). A "-" indicates not sampled.

	CHXO		OSB			ISB				
Segment	BT	DTN	EF	B T	DTN	BS	SGN	EF	BT	DTN
3	-	0.00	0.00	-	0.00	0.00	-	-	-	0.00
5	0.00	0.00	0.01	0.00	0.07	0.10	-	0.03	0.00	0.00
6	0.00	0.00	-	-	-	0.00	-	-	-	-
7	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
9	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
12	0.00	0.00	0.00	0.00	0.00	0.00	-	-	-	-
14	0.00	0.00	0.02	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
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	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
21	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
23	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	0.10	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

Table 54. Relative abundance of walleye collected in 18 Missouri River study segments in discrete macrohabitats (secondary channels connected-SCC; secondary channels non-connected-SCN; tributary mouths-TRM) during 1996. Relative abundance in the various gears are #/100 m in drifting trammel nets (DTN) and a benthic trawl (BT); #/hr in stationary gill nets (SGN); #/min with boat electrofishing (EF); and #/180 degree shoreline haul with a bag seine (BS). A "-" indicates not sampled.

	SCC			SCN		TRM			
Segment	BT	DTN	BS	SGN	BS	EF	SGN	BT	DTN
3	-	-	0.00	-	-	-	-	-	-
5	0.00	0.00	0.00	0.00	0.00	-	-	-	-
6	-	-	0.00	0.13	0.00	-	0.00	-	-
7	0.00	0.00	0.00	0.00	0.00	-	0.00	-	-
8	0.00	0.00	0.00	0.06	0.00	-	0.17	-	-
9	0.33	0.00	0.00	0.00	0.00	-	-	-	-
10	0.00	0.00	0.00	0.00	0.00	-	-	-	-
12	0.00	0.00	0.00	0.00	0.00	0.16	0.42	-	-
14	0.00	0.00	0.13	0.00	1.50	0.13	0.07	-	-
15	0.00	0.00	0.10	0.00	0.25	0.05	0.00	-	-
17	-	-	-	-	-	0.03	0.00	-	0.00
18	0.00	0.00	-	-	-	0.00	0.07	0.00	0.00
19	0.00	-	0.00	-	-	0.01	0.00	-	0.00
21	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
23	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
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-

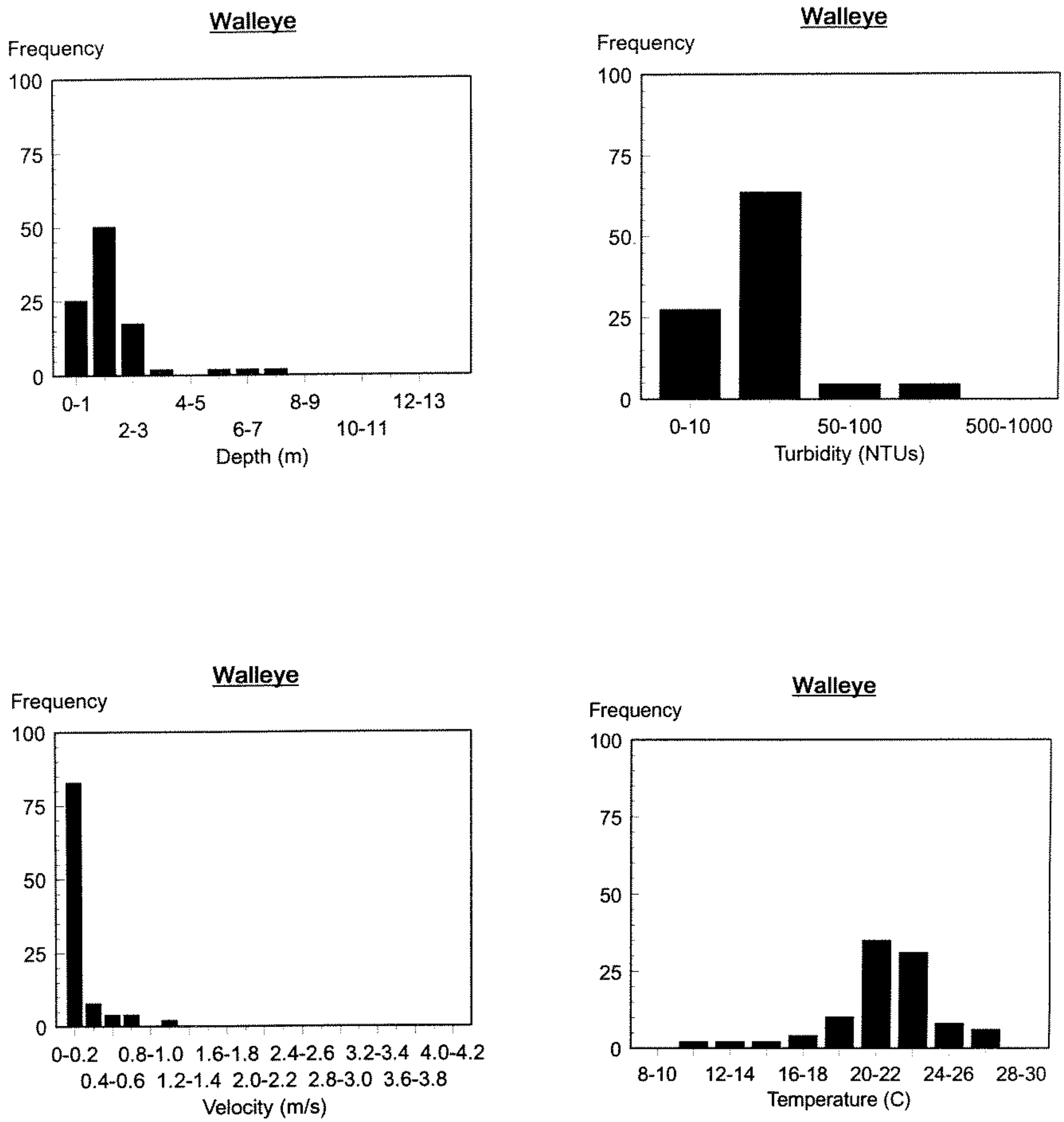


Figure 78. Frequency of occurrence of walleye (N=50) in various depth, velocity, turbidity, and water temperature intervals from Missouri and Lower Yellowstone River collections in 1996.

Walleye lengths varied between 0-50 and 650-700 mm length intervals (Figure 79). The largest walleye was between 650 and 700 mm and captured in section *7* which also had the only walleye < 50 mm. Too few fish were collected for additional interpretation.

Sauger (SGER)

Sauger (N=110) were collected throughout the river in 1996. Forty-eight percent were captured in channelized segments, 25% in inter-reservoir segments and 27% in least-impacted segments. They were collected by all gears and in all macro- and meso-habitats (Figure 80; Tables 55 and 56). They were collected in CHXOs in least-impacted segments, but not in inter-reservoir or channelized segments. In channelized segments most were collected in TRMs and ISBs. Non-standardized electrofishing procedures and consequently not shown in Tables 39 and 40, yielded catch rates (#/min) of 0.20 in segment *17* ISB-BARS and 0.03 in segment **15** SCN (i.e., cattail marshes).

Most sauger were captured in shallow depths (65% in depths < 1 m), slow velocities (75% in velocities < 0.4 m/s), and clear waters (70% in turbidities from 10 to 50 NTUs) (Figure 81). Like walleye, sauger were collected in a wide range of water temperatures (8-30 °C), with most in warmer waters (about 80% in temperatures between 20 and 28 °C).

Sauger varied in length between 0-50 and 650-700 mm length intervals, with a central tendency of 300-350 mm in most sections (Figure 82).

Freshwater drum (FWDM)

Freshwater drum were common (i.e., 476 collected) throughout the river in 1996. Most (78%) were collected in channelized segments in ISBs, SCC, SCN, and TRMs. Twelve percent were collected in least-impacted segments in ISBs, OSBs, and SCN. Ten percent were captured in inter-reservoir segments. They were only absent from collections in segments **6, 7, 12**, and **14**, all immediately below the largest Missouri River impoundments in this study (i.e., Fort Peck Lake (segments **6** and **7**), Lake Sakakawea (segment **12**), and Lake Francis Case (segment **14**)). They were collected in all macro- and meso-habitats except

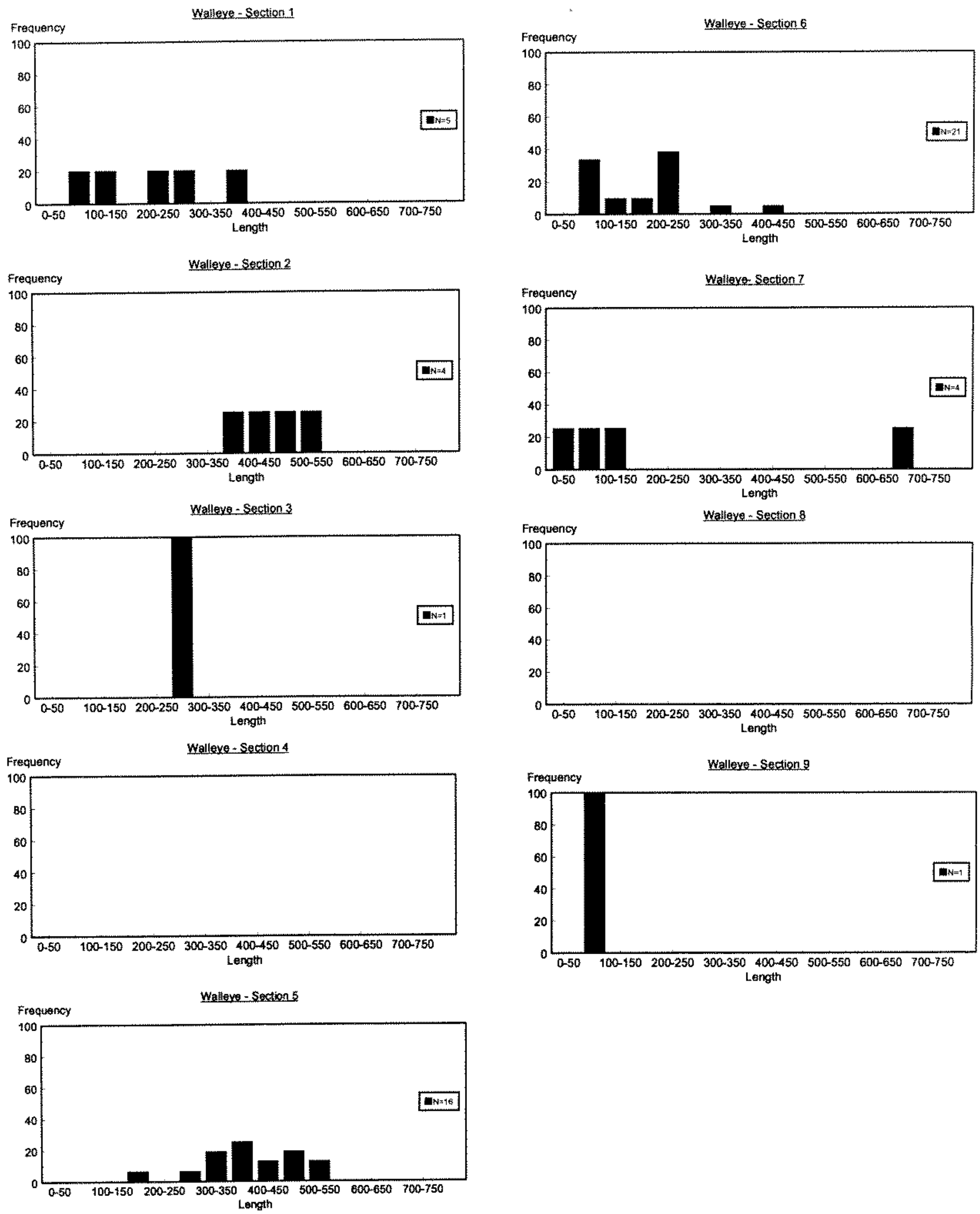


Figure 79. Length-frequency histograms of walleye collected in Missouri River study sections during 1996 by drifting trammel nets, experimental gill nets, a benthic trawl, bag seine, and by boat electrofishing.

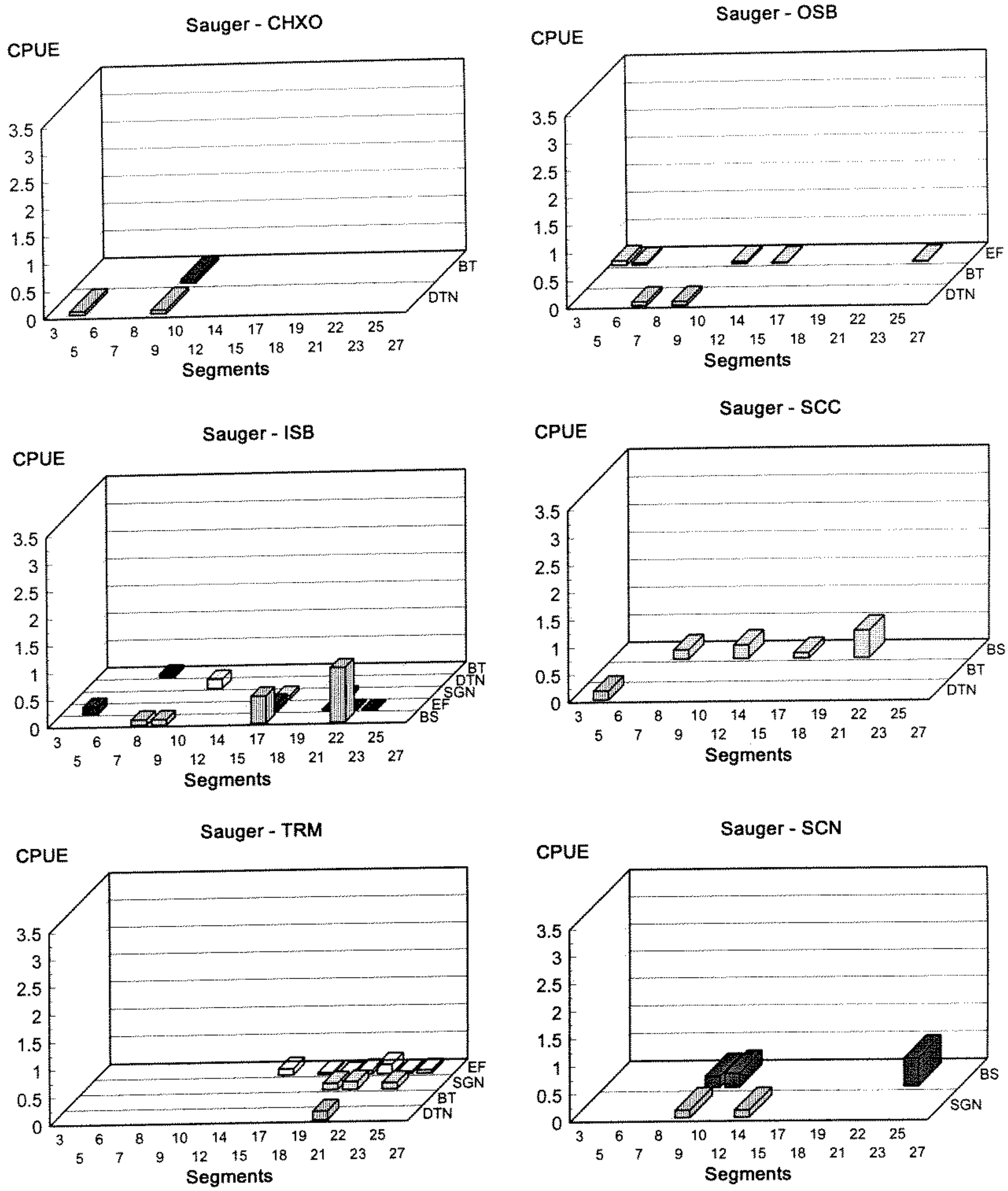


Figure 80. Trends in sauger catch rates among Missouri River study segments and macrohabitats in 1996. Catch rates for a benthic trawl (BT) and drifting trammel net (DTN) are #/100 m, for a bag seine (BS) - #/180 degree haul, experimental gill net (SGN) - #/hr, and electrofishing (EF) - #/min. See Appendix A for macrohabitat acronyms.

Table 55. Relative abundance of sauger collected in 18 Missouri River study segments in continuous macrohabitats (channel crossover-CHXO; outside bend-OSB; and inside bend-ISB) during 1996. Relative abundance in the various gears are #/100 m in drifting trammel nets (DTN) and a benthic trawl (BT); #/hr in stationary gill nets (SGN); #/min with boat electrofishing (EF); and #/180 degree shoreline haul with a bag seine (BS). A "-" indicates not sampled.

	CHXO		OSB			ISB				
Segment	BT	DTN	EF	BT	DTN	BS	SGN	EF	BT	DTN
3	-	0.00	0.10	-	0.00	0.00	-	-	-	0.00
5	0.00	0.07	0.04	0.00	0.00	0.00	-	0.13	0.00	0.00
6	0.00	0.00	-	-	-	0.00	-	-	-	-
7	0.00	0.00	-	0.00	0.07	0.00	-	-	0.07	0.00
8	0.00	0.00	-	0.00	0.00	0.10	0.00	-	0.00	0.00
9	0.07	0.07	-	0.00	0.07	0.10	0.00	-	0.00	0.00
10	0.00	0.00	0.04	0.00	0.00	0.00	-	-	0.00	0.17
12	0.00	0.00	0.00	0.00	0.00	0.00	-	-	-	-
14	0.00	0.00	0.02	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
17	0.00	0.00	0.00	0.00	0.00	0.50	0.07	0.15	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	-	0.00	0.10	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	-	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.01	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.03	0.00	0.00
23	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.01	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
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 56. Relative abundance of sauger collected in 18 Missouri River study segments in discrete macrohabitats (secondary channels connected-SCC; secondary channels non-connected-SCN; tributary mouths-TRM) during 1996. Relative abundance in the various gears are #/100 m in drifting trammel nets (DTN) and a benthic trawl (BT); #/hr in stationary gill nets (SGN); #/min with boat electrofishing (EF); and #/180 degree shoreline haul with a bag seine (BS). A "-" indicates not sampled.

	SCC			SCN		TRM			
Segment	BT	DTN	BS	SGN	BS	EF	SGN	BT	DTN
3	-	-	0.00	-	-	-	-	-	-
5	0.00	0.17	0.00	0.00	0.00	-	-	-	-
6	-	-	0.00	0.00	0.00	-	0.00	-	-
7	0.00	0.00	0.17	0.00	0.00	-	0.00	-	-
8	0.00	0.00	0.00	0.00	0.00	-	0.00	-	-
9	0.00	0.00	0.00	0.13	0.20	-	-	-	-
10	0.00	0.00	0.25	0.00	0.25	-	-	-	-
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-
14	0.00	0.00	0.00	0.13	0.00	0.00	0.00	-	-
15	0.00	0.00	0.10	0.00	0.00	0.11	0.00	-	-
17	-	-	-	-	-	0.00	0.00	-	0.00
18	0.00	0.00	-	-	-	0.04	0.00	0.00	0.00
19	0.00	-	0.50	-	-	0.01	0.12	-	0.00
21	0.00	0.00	-	-	-	0.06	0.14	0.00	0.17
22	-	-	0.00	0.00	0.00	0.17	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.50	0.04	0.12	0.00	0.00
25	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.00
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-

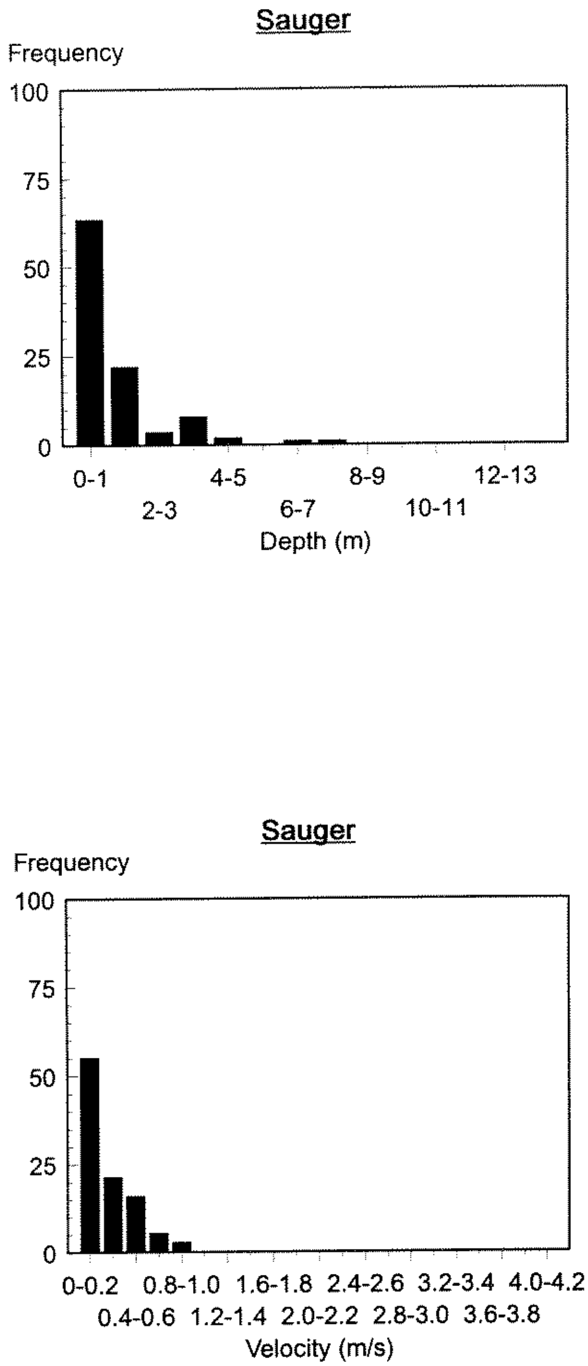


Figure 81. Frequency of occurrence of sauger (N=109) in various depth, velocity, turbidity, and water temperature intervals from Missouri and Lower Yellowstone River collections in 1996.

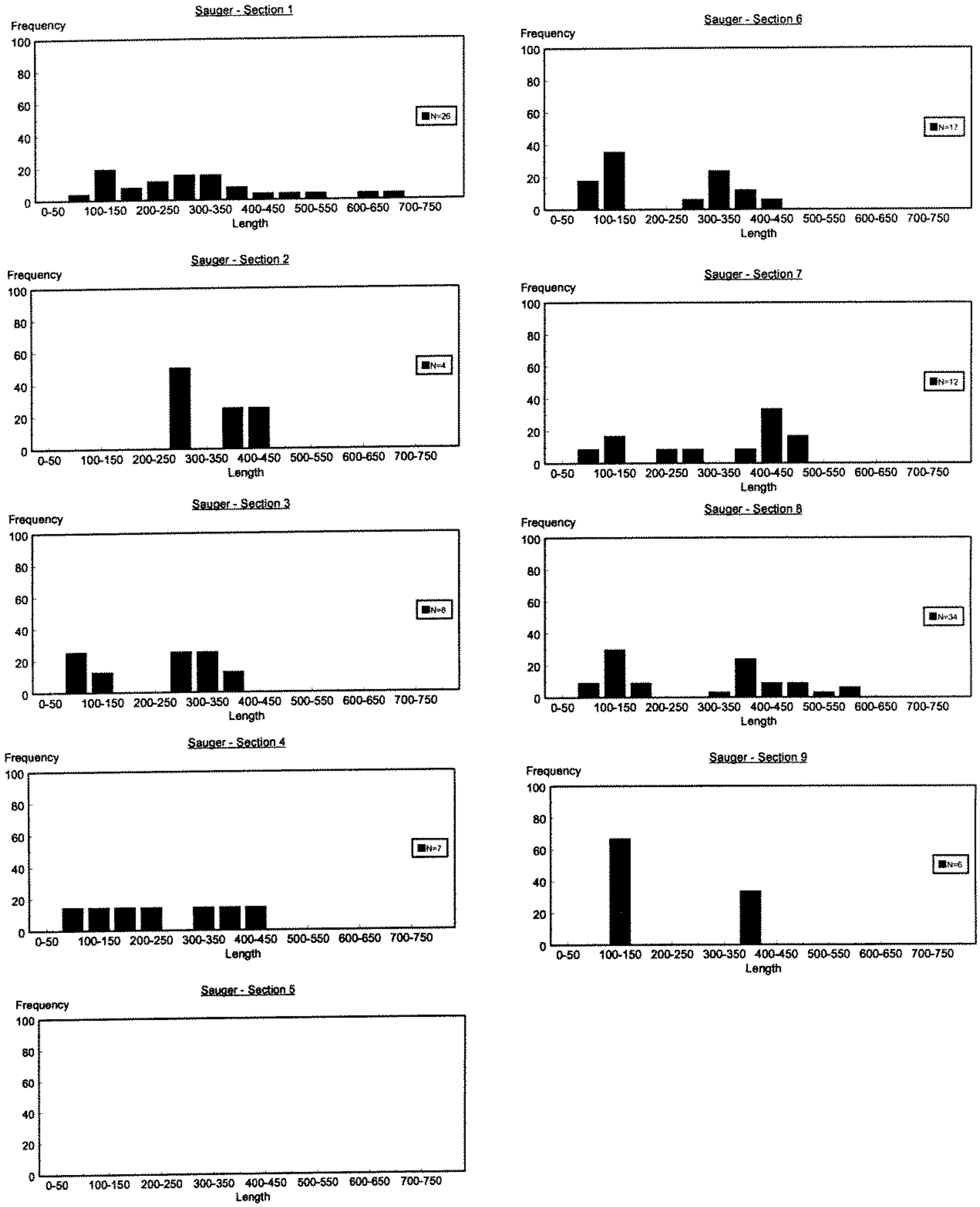


Figure 82. Length-frequency histograms of sauger collected in Missouri River study sections during 1996 by drifting trammel nets, experimental gill nets, a benthic trawl, bag seine, and by boat electrofishing.

CHXOs (Figure 83; Tables 57 and 58). Non-standardized electrofishing procedures in segment **15** yielded catch rates (#/min) of 0.03 in SCN (i.e., cattail marshes where standardized seining procedures were impossible).

Freshwater drum predominatly used shallow depths (95% in depths < 2 m), slow velocities (80% in velocities < 0.4 m/s), and warm water temperatures (85% in temperatures between 20 and 28 °C) (Figure 84). Conversely, they were collected in a wide range of turbidities (0-1000 NTUs). Freshwater drum percentages generally increased as turbidity increased with the exception of turbidities > 500 NTUs.

Freshwater drum lengths varied between 0-50 and 400-450 mm length intervals with most < 100 mm (Figure 85). Freshwater drum numbers were highest in sections *8* and *9* with 70% of all drum < 100 mm. Freshwater drum < 50 mm, likely indicating good reproduction and good recruitment to our gear were only collected downstream of Fort Randall Dam, SD (i.e., rmi 880.0-0.0; sections **6**, *7*, *8*, and *9*).

Target Benthic Taxa - Discussion

This progress report represents the first ever compilation of physicochemical, fish catch, and fish habitat use information collected in a standardized fashion for the entire Mainstem Missouri and Lower Yellowstone Rivers. While several interesting patterns are evident from the 1996 field season, it is premature to discuss data trends and their implications until after the 1997 field season and without age and growth data to aid interpretations.

Relative Abundance and Distribution

Few individuals of many species discussed in this report were collected in 1996. This was likely due to high water conditions (Figure 1) reducing gear efficiency and low gear effort expended per sample (e.g., 5 minute electrofishing runs and 3 hour gill net sets). SOPs have been modified to increase effort for the 1997 sampling season to help alleviate the latter factor. Low catch rates preclude meaningful statistical comparisons of relative abundance data among segments and macrohabitats at this time. At present, data are split to the lowest

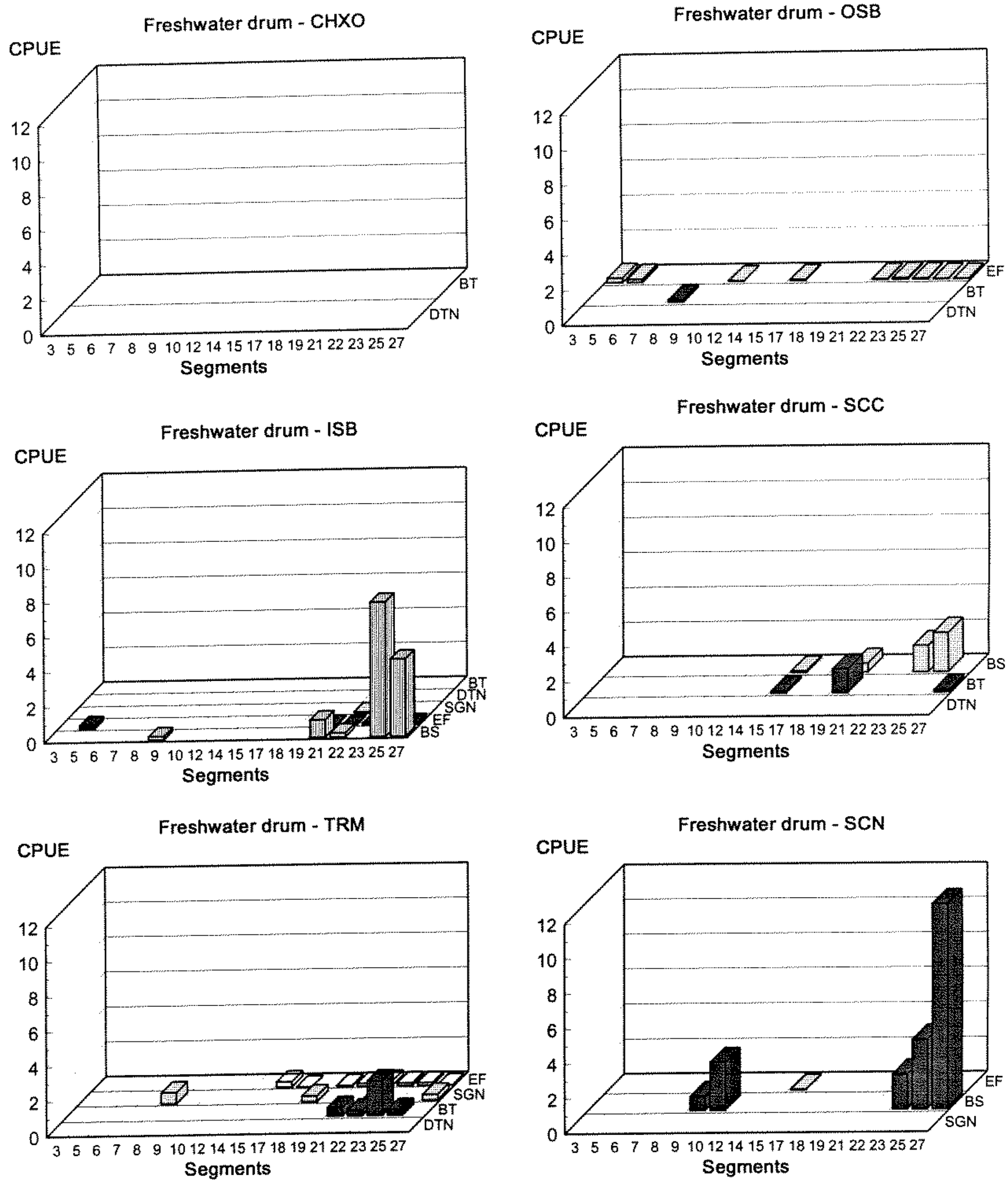


Figure 83. Trends in freshwater drum catch rates among Missouri River study segments and macrohabitats in 1996. Catch rates for a benthic trawl (BT) and drifting trammel net (DTN) are #/100 m, for a bag seine (BS) - #/180 degree haul, experimental gill net (SGN) - #/hr, and electrofishing (EF) - #/min. See Appendix A for macrohabitat acronyms.

Table 57. Relative abundance of freshwater drum collected in 18 Missouri River study segments in continuous macrohabitats (channel crossover-CHXO; outside bend-OSB; and inside bend-ISB) during 1996. Relative abundance in the various gears are #/100 m in drifting trammel nets (DTN) and a benthic trawl (BT); #/hr in stationary gill nets (SGN); #/min with boat electrofishing (EF); and #/180 degree shoreline haul with a bag seine (BS). A "-" indicates not sampled.

	CHXO		OSB			ISB				
Segment	BT	DTN	EF	BT	DTN	BS	SGN	EF	BT	DTN
3	-	0.00	0.25	-	0.00	0.00	-	-	-	0.00
5	0.00	0.00	0.18	0.00	0.00	0.00	-	0.21	0.00	0.00
6	0.00	0.00	-	-	-	0.00	-	-	-	-
7	0.00	0.00	-	0.00	0.00	0.00	-	-	0.00	0.00
8	0.00	0.00	-	0.13	0.00	0.00	0.00	-	0.00	0.00
9	0.00	0.00	-	0.00	0.00	0.20	0.00	-	0.00	0.00
10	0.00	0.00	0.01	0.00	0.00	0.00	-	-	0.00	0.00
12	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
15	0.00	0.00	0.05	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
18	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
21	0.00	0.00	0.06	0.00	0.00	1.00	0.00	0.06	0.00	0.00
22	0.00	0.00	0.11	0.00	0.00	0.25	0.05	0.02	0.07	0.00
23	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.09	0.00	0.00
25	0.00	0.00	0.03	0.00	0.00	7.70	0.00	0.00	0.00	0.00
27	0.00	0.00	0.01	0.00	0.00	4.40	0.00	0.08	0.00	0.00

Table 58. Relative abundance of freshwater drum collected in 18 Missouri River study segments in discrete macrohabitats (secondary channels connected-SCC; secondary channels non-connected-SCN; tributary mouths-TRM) during 1996. Relative abundance in the various gears are #/100 m in drifting trammel nets (DTN) and a benthic trawl (BT); #/hr in stationary gill nets (SGN); #/min with boat electrofishing (EF); and #/180 degree shoreline haul with a bag seine (BS). A "-" indicates not sampled.

	SCC			SCN		TRM			
Segment	BT	DTN	BS	SGN	BS	EF	SGN	BT	DTN
3	-	-	0.00	-	-	-	-	-	-
5	0.00	0.00	0.00	0.00	0.00	-	-	-	-
6	-	-	0.00	0.00	0.00	-	0.00	-	-
7	0.00	0.00	0.00	0.00	0.00	-	0.00	-	-
8	0.00	0.00	0.00	0.00	0.00	-	0.63	-	-
9	0.00	0.00	0.00	0.00	0.80	-	-	-	-
10	0.00	0.00	0.00	0.00	2.75	-	-	-	-
12	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	-	-
15	0.11	0.00	0.10	0.00	0.00	0.31	0.00	-	-
17	-	-	-	-	-	0.01	0.00	-	0.00
18	0.00	0.00	-	-	-	0.00	0.33	0.00	0.00
19	1.33	-	0.50	-	-	0.05	0.00	-	0.00
21	0.00	0.00	-	-	-	0.15	0.00	0.50	0.00
22	-	-	0.00	0.00	0.00	0.26	0.07	0.33	0.00
23	0.00	0.00	1.50	0.00	2.00	0.15	0.00	2.00	0.00
25	0.00	0.00	2.25	0.00	4.00	0.16	0.00	0.33	0.00
27	0.11	0.00	0.00	0.00	11.75	0.02	0.33	-	-

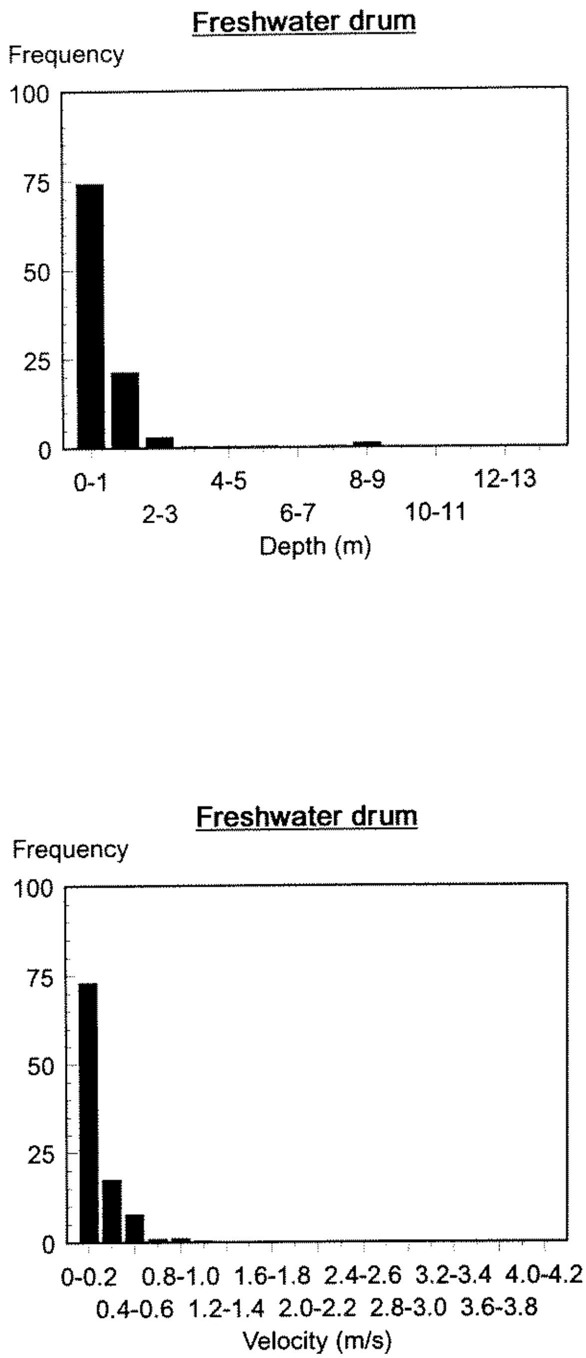


Figure 84. Frequency of occurrence of freshwater drum (N=475) in various depth, velocity, turbidity, and water temperature intervals from Missouri and Lower Yellowstone River collections in 1996.

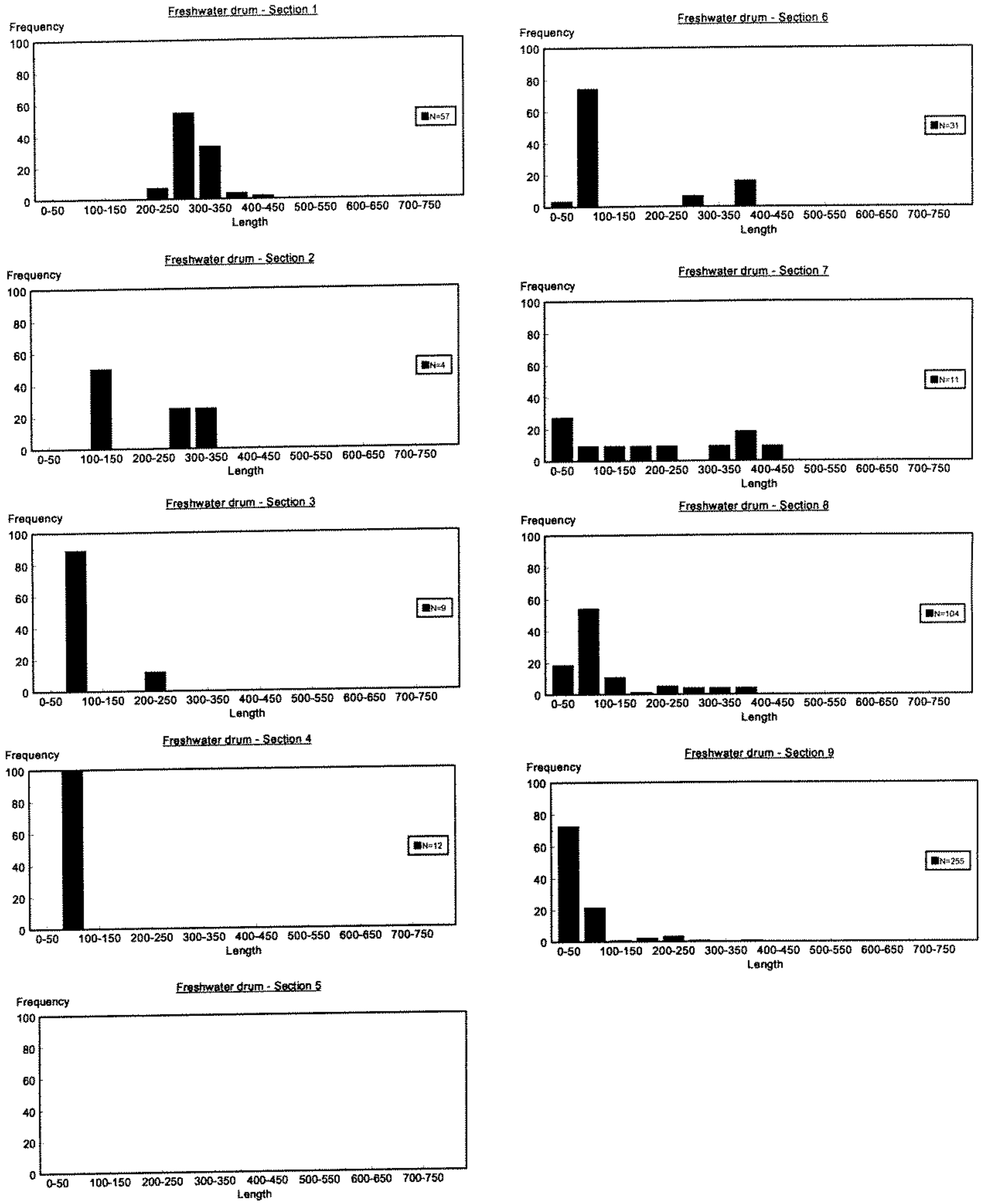


Figure 85. Length-frequency histograms of freshwater drum collected in Missouri River study sections during 1996 by drifting trammel nets, experimental gill nets, a benthic trawl, bag seine, and by boat electrofishing.

common denominator (i.e., catch rates by species, gear, macrohabitat and segment). At this level, large numbers of zeros yield a non-normal distribution. For example, for a given species collected with a particular gear, a maximum of about 25 relative abundance observations per segment (i.e., 5 replicates x a maximum of 5 macrohabitats per gear) are possible. About 15 observations per segment (i.e., observations with fish) are recommended to facillitate statistical analyses. The number of observations per segment may be increased as follows: 1) collect more data within and across years and 2) pool data; across gears, macrohabitats, or gears and macrohabitats combined. A hypothetical illustration of this is presented in Table 59. The illustration is hypothetical because the maximum number of possible observations across all gears will not equal 95, as indicated in Table 59. Rather, some macrohabitats are sampled with more than one gear, so the actual maximum number is somewhat lower. The number of observations by gear and segment (macrohabitats pooled) is only > 10 in segments 21, 22, and 23 with electrofishing, and in segment 23 with the benthic trawl and none of these are > 15. However, by lumping across gears, 7 of 18 segments have > 15 observations and 11 of 18 segments have > 10 observations. Such ecologically meaningful ways of combining data will be explored further once additional data are collected in the 1997 and 1998 field seasons.

Some general distributional patterns were evident even though statistical comparisons of relative abundance data for most species were not possible at this time. Fifteen taxa, shovelnose sturgeon, common carp, sturgeon chub, sicklefin chub, emerald shiner, sand shiner, *Hybognathus* spp., blue sucker, bigmouth buffalo, smallmouth buffalo, river carpsucker, channel catfish, walleye, sauger, and freshwater drum were collected throughout the Missouri and Lower Yellowstone River. Six species, flathead chub, fathead minnow, white sucker, shorthead redhorse, stonecat, and burbot were primarily collected in least impacted and inter-reservoir segments. Two species, blue catfish and flathead catfish were only collected in channelized segments. As all target benthic species are reported to have had a historic range that included five of the six states being sampled, their current presence or absence in some states may reflect; 1) historic rarity, 2) environmental changes (e.g., increased velocity and depth in channelized segments), 3) sampling bias (e.g., some species

Table 59. The number of observations of channel catfish collected (i.e., observations in which a channel catfish has been collected) by segment and gear across all macrohabitats (i.e., macrohabitat observations lumped) in the Missouri River in 1996. Sum= the number of observations per segment after gears are lumped. Numbers in ( ) indicate maximum number of observations possible. The sum of all maximum observations would equal 95 in this example. However, in practice this number would be considerably less because most macrohabitats are sampled with more than one gear.

Segment	Gear					Sum
	Trammel net (25)	Benthic trawl (25)	Electrofishing (15)	Gill net (15)	Bag seine (15)	
3	0	0	2	0	0	2
5	1	2	3	2	0	8
6	0	0	0	1	0	1
7	0	0	0	0	0	0
8	0	0	0	2	0	2
9	9	9	0	3	6	27
10	2	3	0	2	1	8
12	0	0	0	0	0	0
14	6	0	2	2	0	10
15	2	2	9	1	2	16
17	0	8	4	0	0	12
18	0	3	9	1	0	13
19	0	4	8	0	1	13
21	1	4	11	1	1	18
22	1	4	11	3	3	22
23	2	10	10	1	4	27
25	0	4	8	0	6	18
27	0	2	9	2	5	18

like shorthead redhorse may be more readily captured in late spring and early autumn), or 4) low sampling effort.

Habitat Use

Habitat use information was presented for 23 taxa in this report. Most trends among species were similar and may reflect adaptations to historic habitat conditions or gear capture efficiences. Depth and velocity patterns for all species were skewed to shallow depths (generally < 2 m) and slower velocities (generally < 0.6 m/s) (Figures 86 and 87). A predominance of shallow depths (average depth over sandbars was 0.8 m) and moderate velocities was considered characteristic of the Middle Missouri River before impoundment and channelization (Latka et al. 1993; Slizeski et al. 1982). Taxa with high percentages (> 75%) in shallow water and slow velocity areas were common carp, flathead chub, sand shiner, *Hybognathus* spp., fathead minnow, bigmouth buffalo, smallmouth buffalo, river carpsucker, shorthead redhorse, white sucker, burbot, walleye, sauger, and freshwater drum. Species that had high percentages in deeper water (2-6 m) and faster velocity (0.6-1.2 m/s) areas included shovelnose sturgeon, sturgeon chub, sicklefin chub, blue sucker, blue catfish, and stonecat. Turbidity and water temperature patterns were more variable (Figures 88 and 89). No species had their highest percentages in the most turbid (> 500 NTUs), warm waters (> 28 °C). Only blue catfish and freshwater drum had their highest percentages in moderately turbid waters (100-500 NTUs). Remaining species were generally collected in waters with turbidities < 100 NTUs. All species except white sucker had their highest percentages in moderately warm waters (18-28 °C). White suckers were generally collected in cool water temperatures (< 18 °C).

These patterns may reflect evolutionary adaptations to Missouri River habitat conditions (shallow depths and moderate velocities, discussed above), sampling biases, and availability of specific micro- and macro-habitats. Subsequent year's information (e.g., habitat availability information) is required before we evaluate these possibilities further.

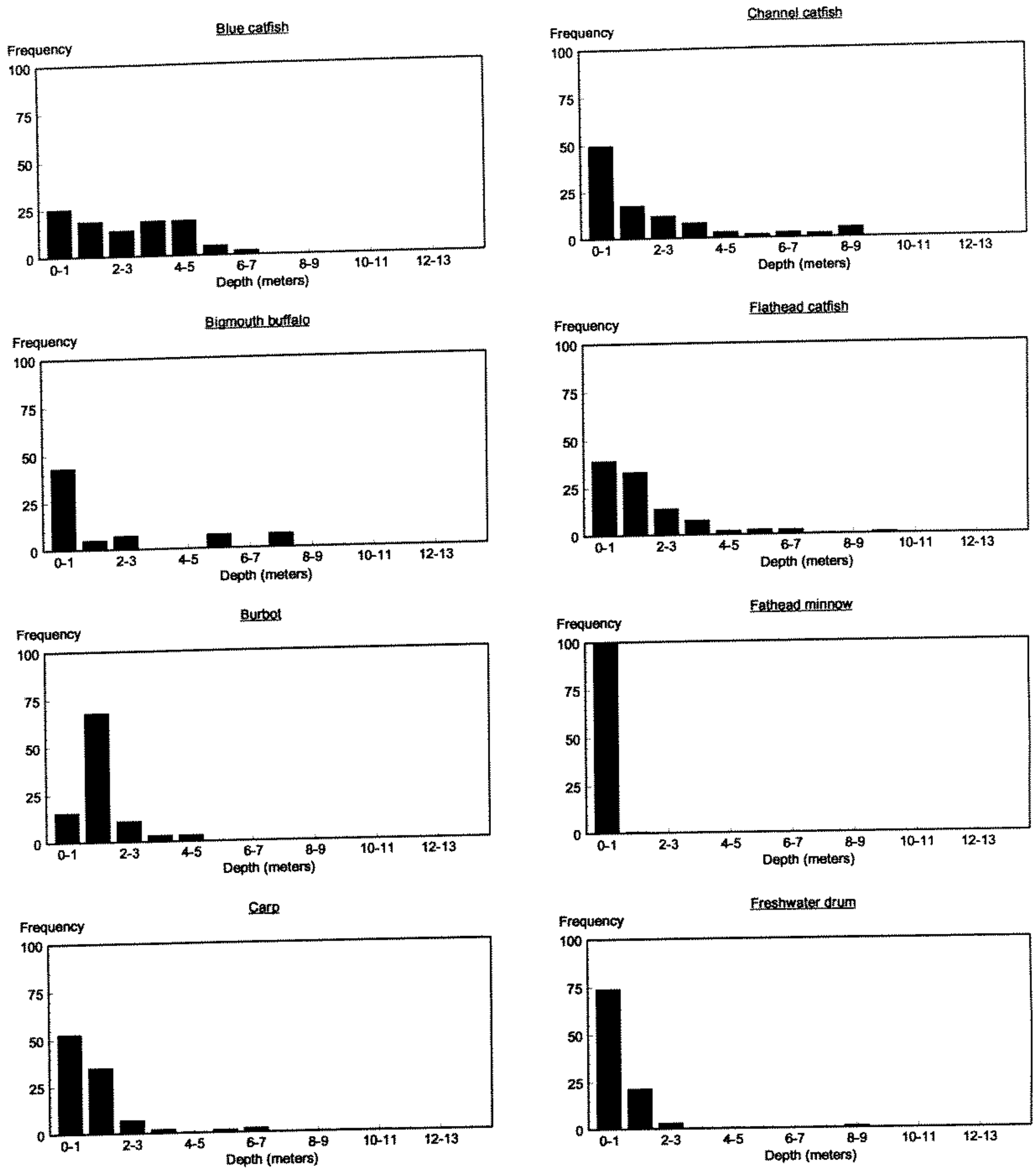
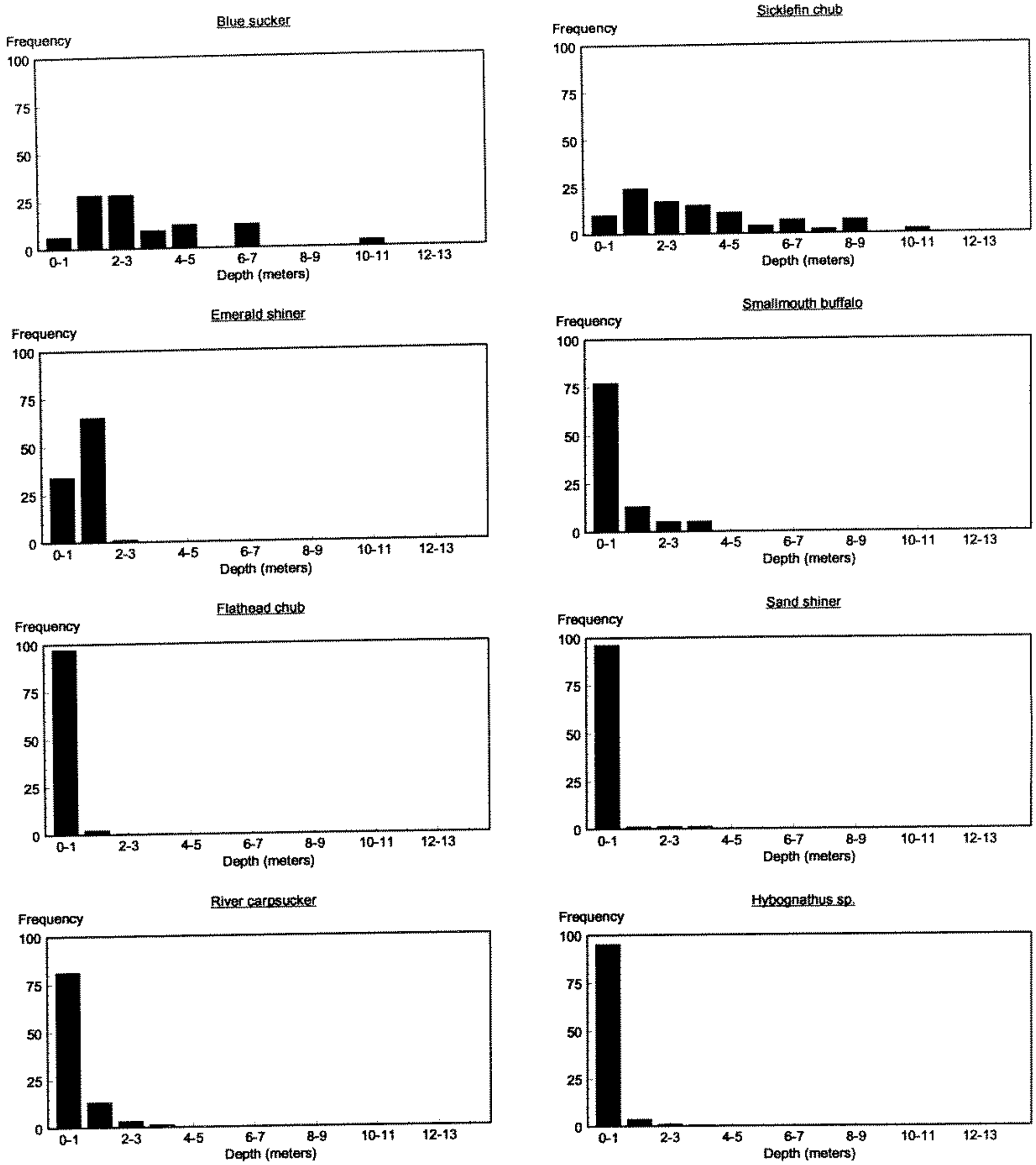


Figure 86. The frequency of occurrence of individuals of 23 Missouri and Lower Yellowstone River benthic fish taxa collected in various depth intervals in 1996.



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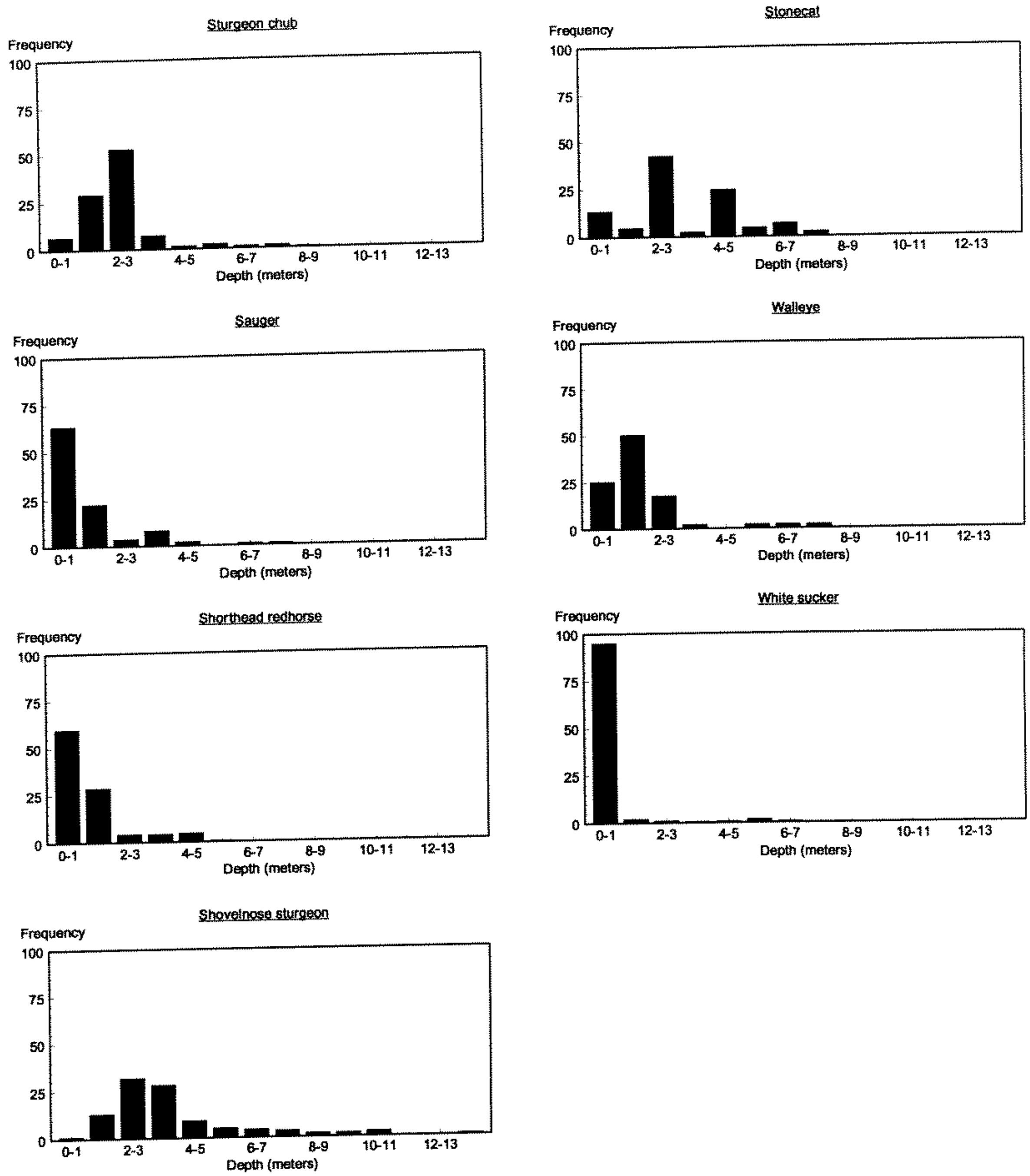

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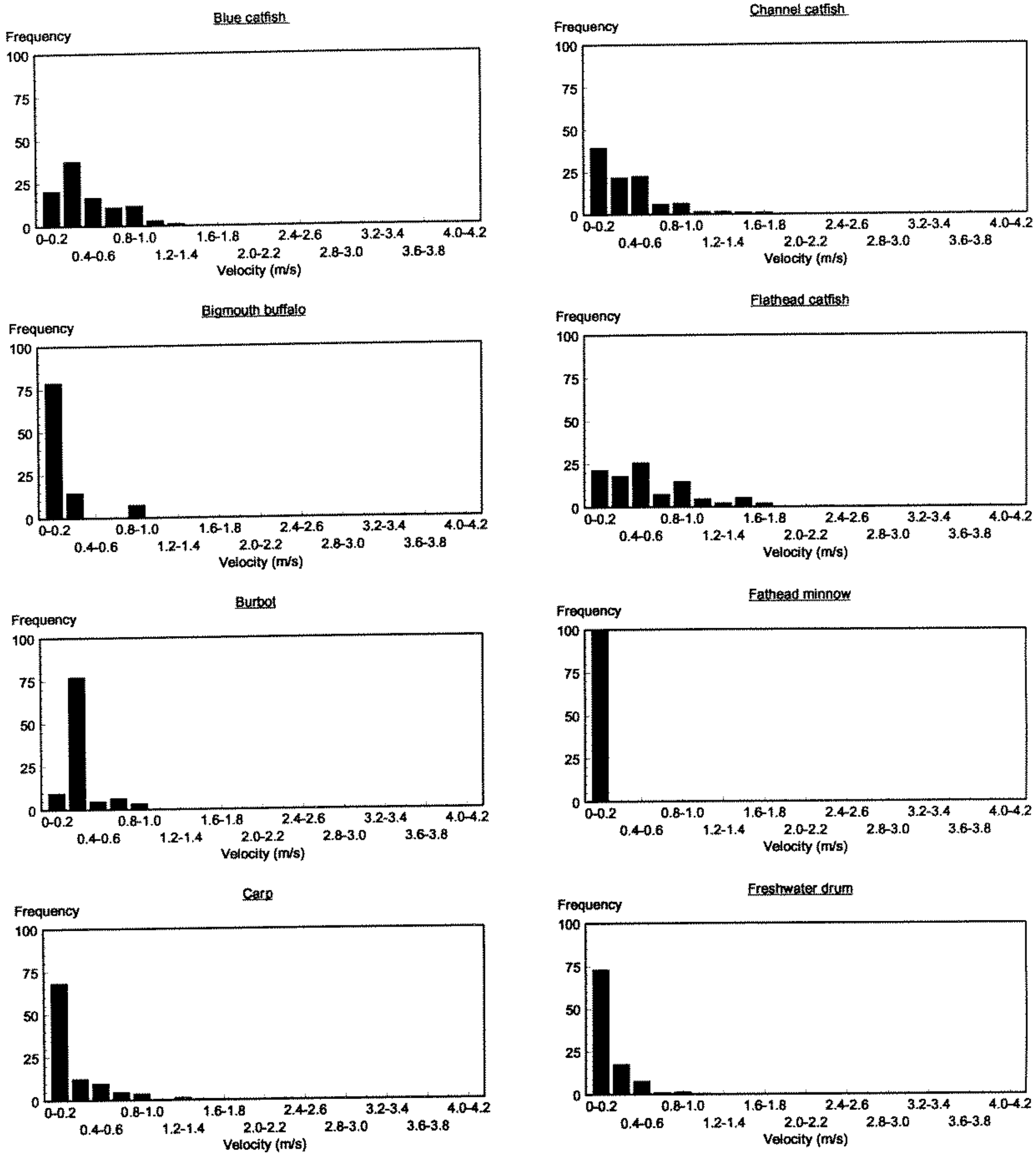
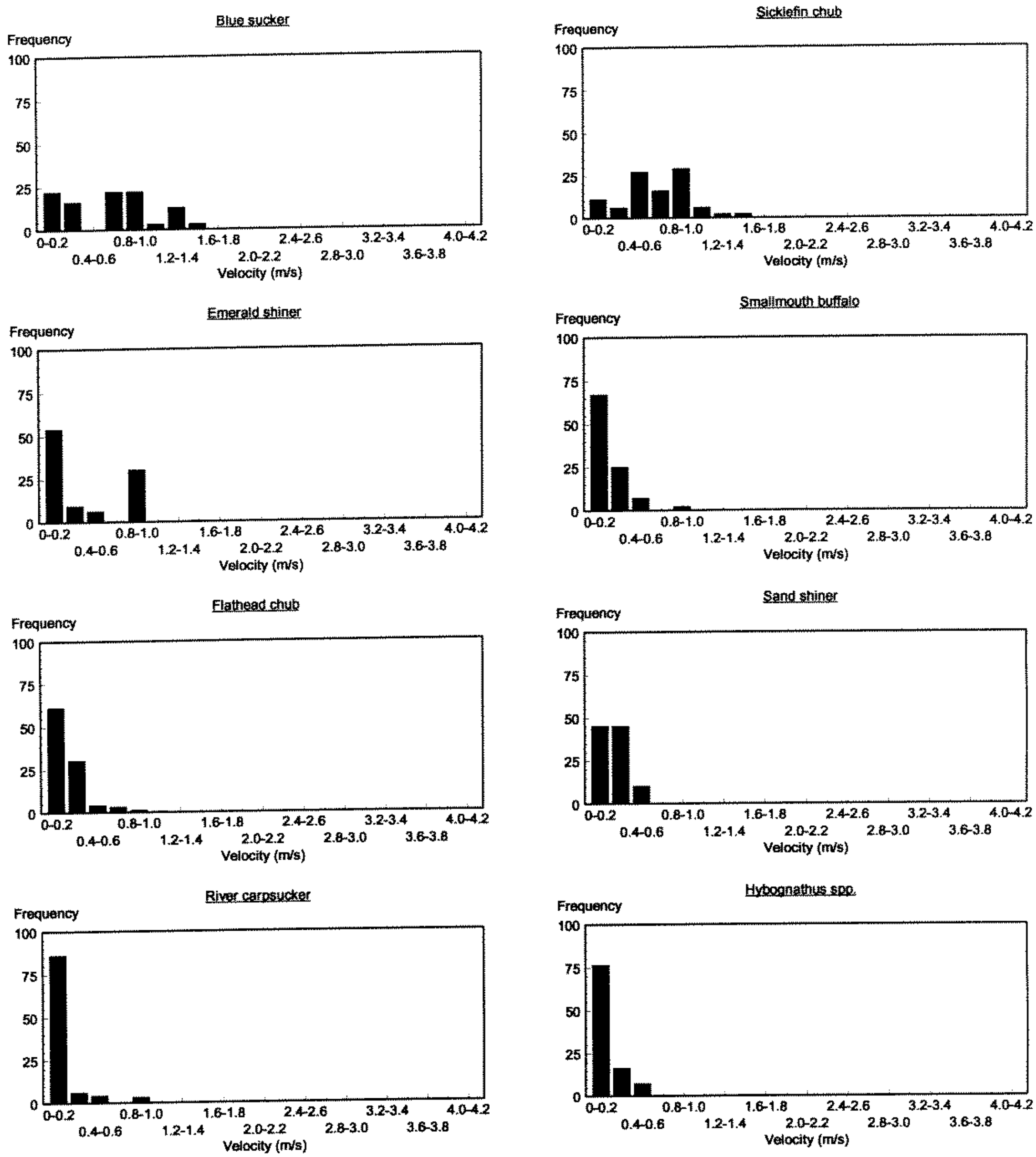


Figure 87. The frequency of occurrence of individuals of 23 Missouri and Lower Yellowstone River benthic fish taxa collected in various velocity intervals in 1996.



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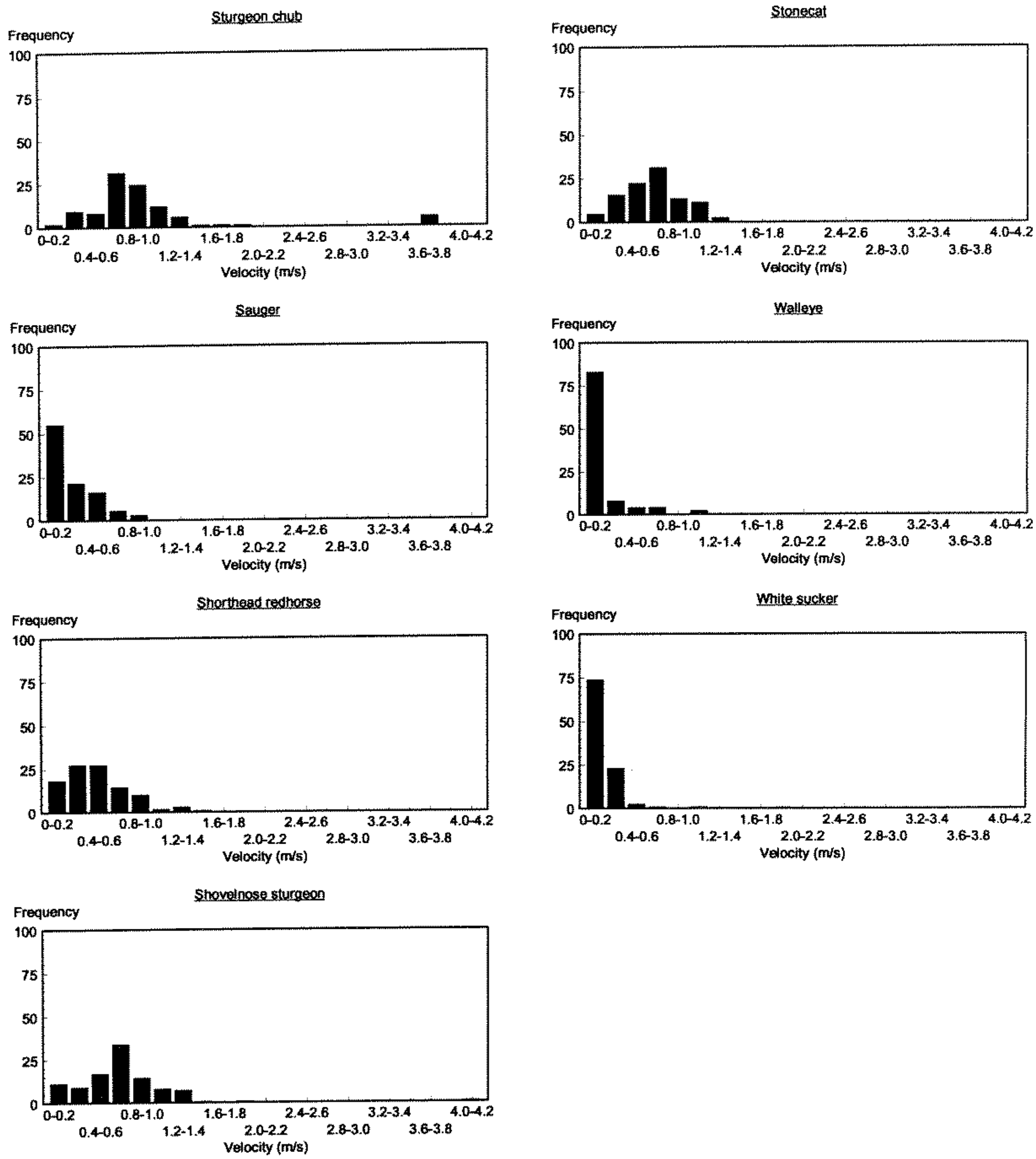

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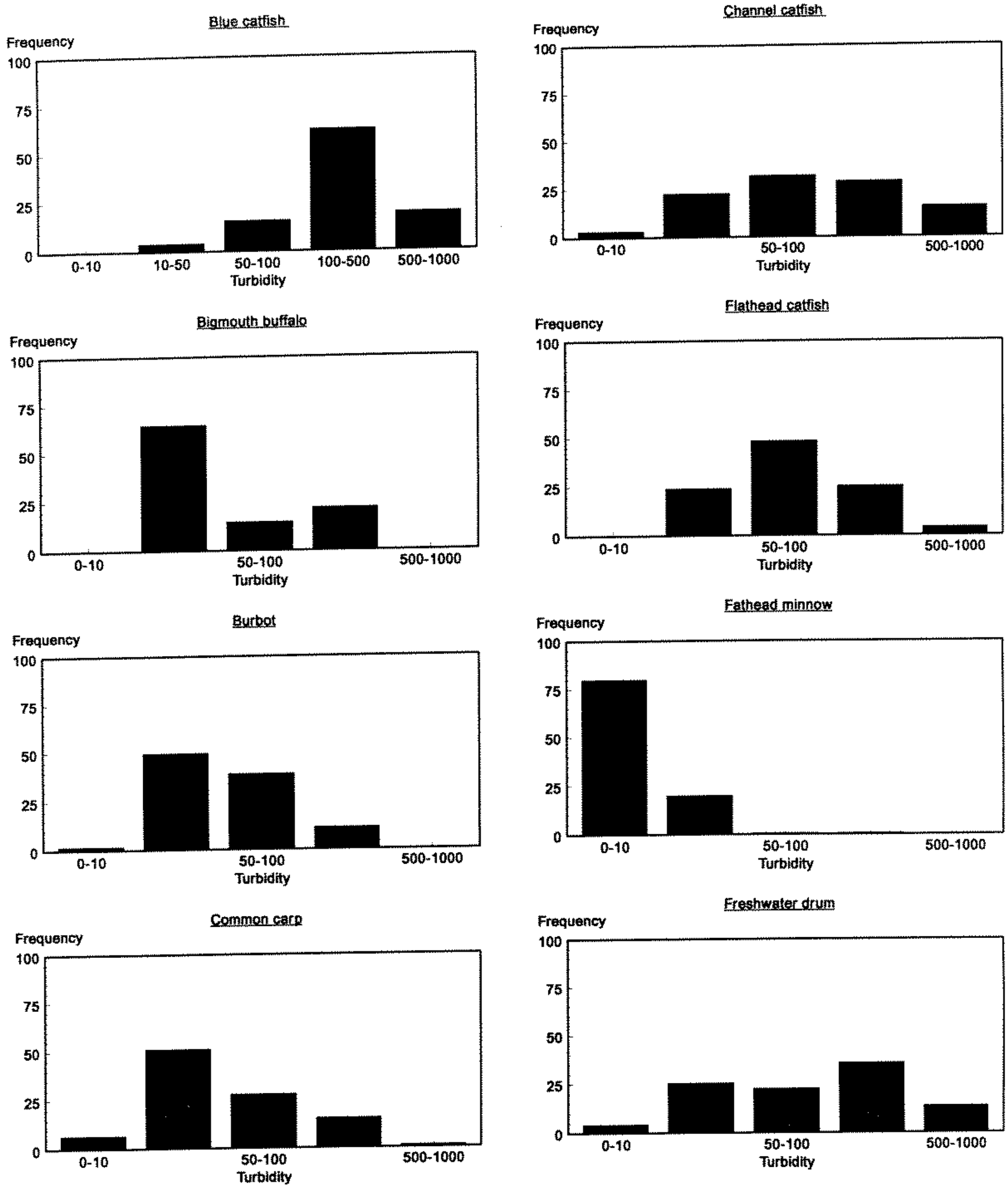


Figure 88. The frequency of occurrence of individuals of 23 Missouri and Lower Yellowstone River benthic fish taxa collected in various turbidity intervals in 1996.

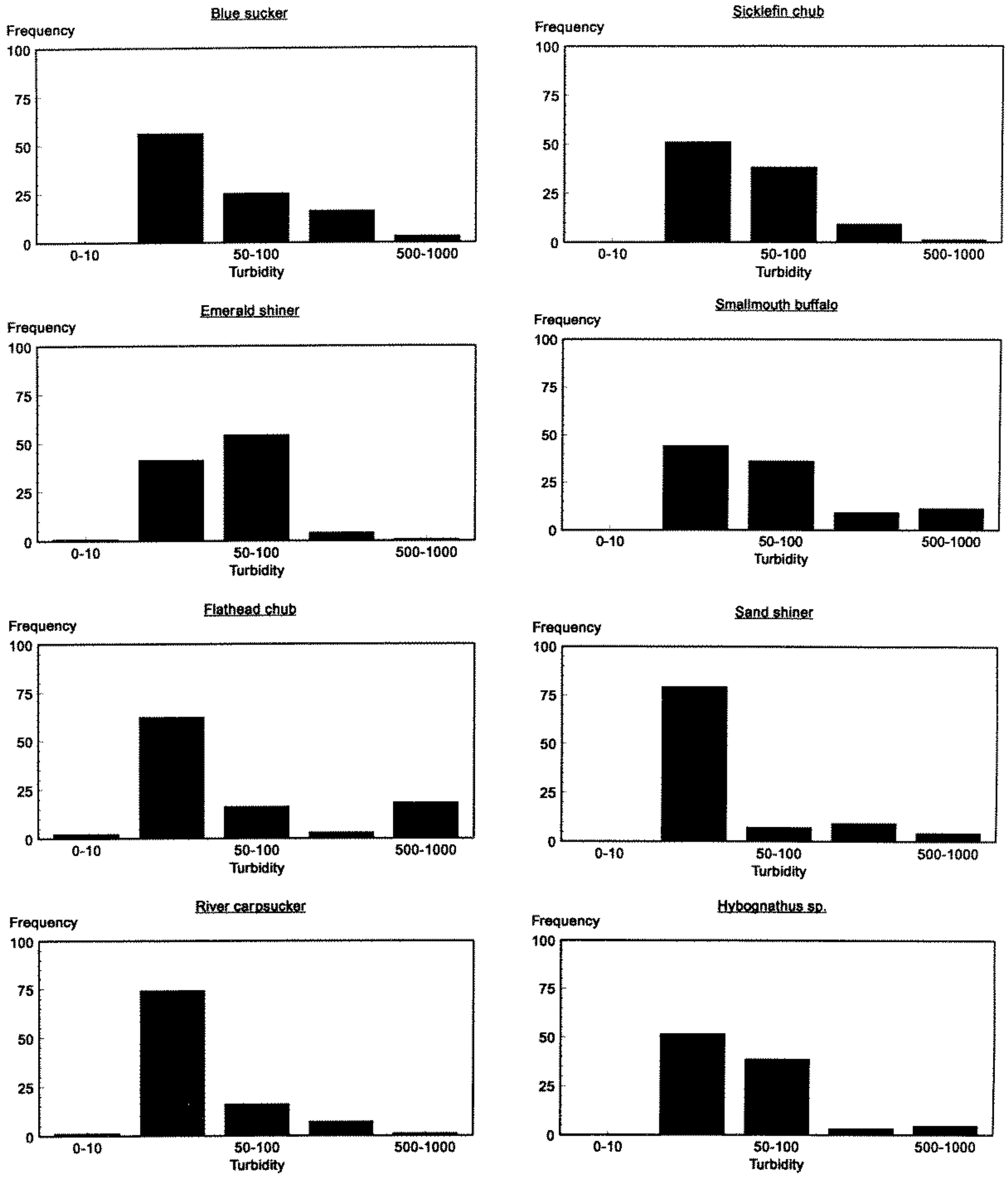


Figure 88. Continued.

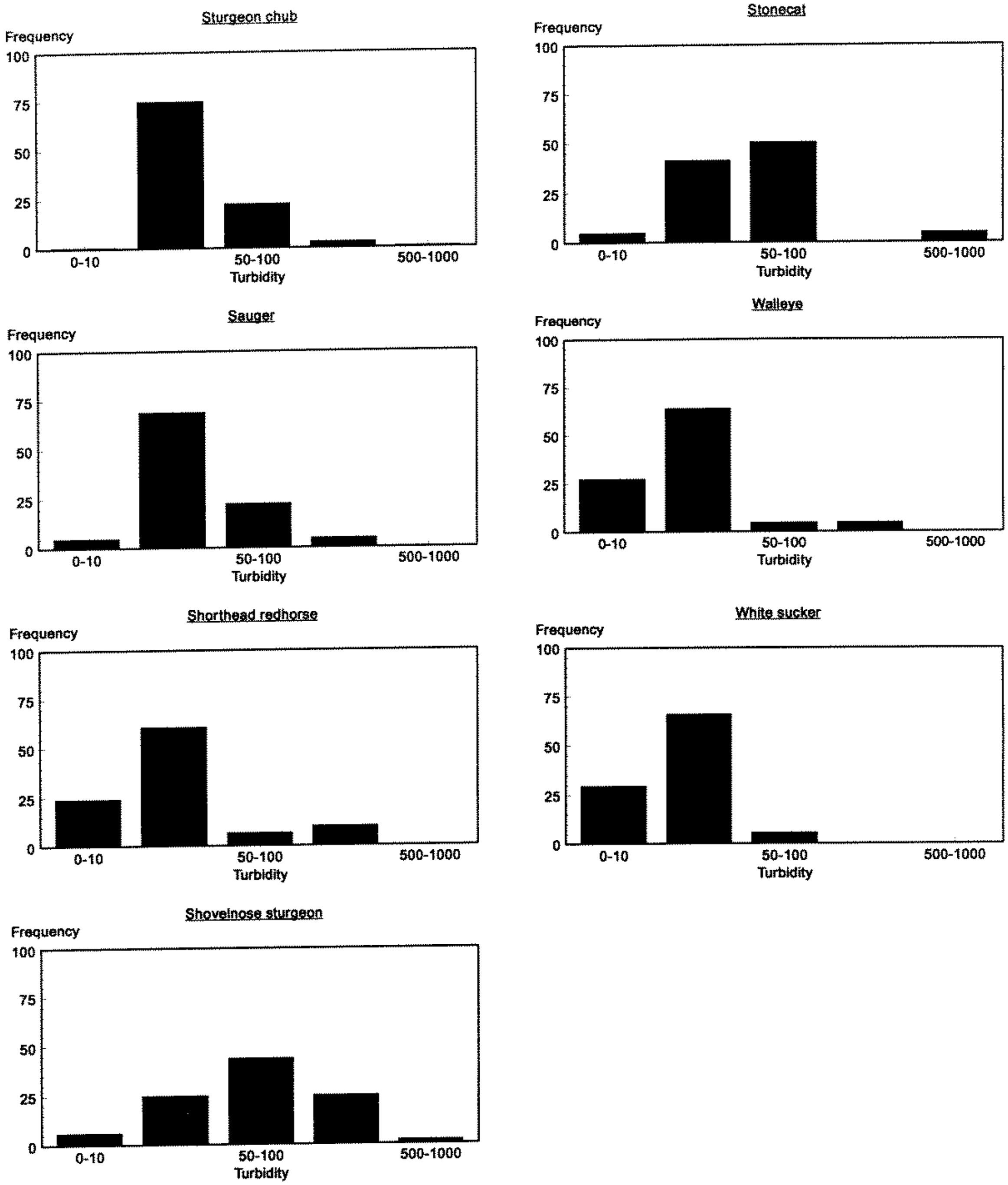


Figure 88. Continued.

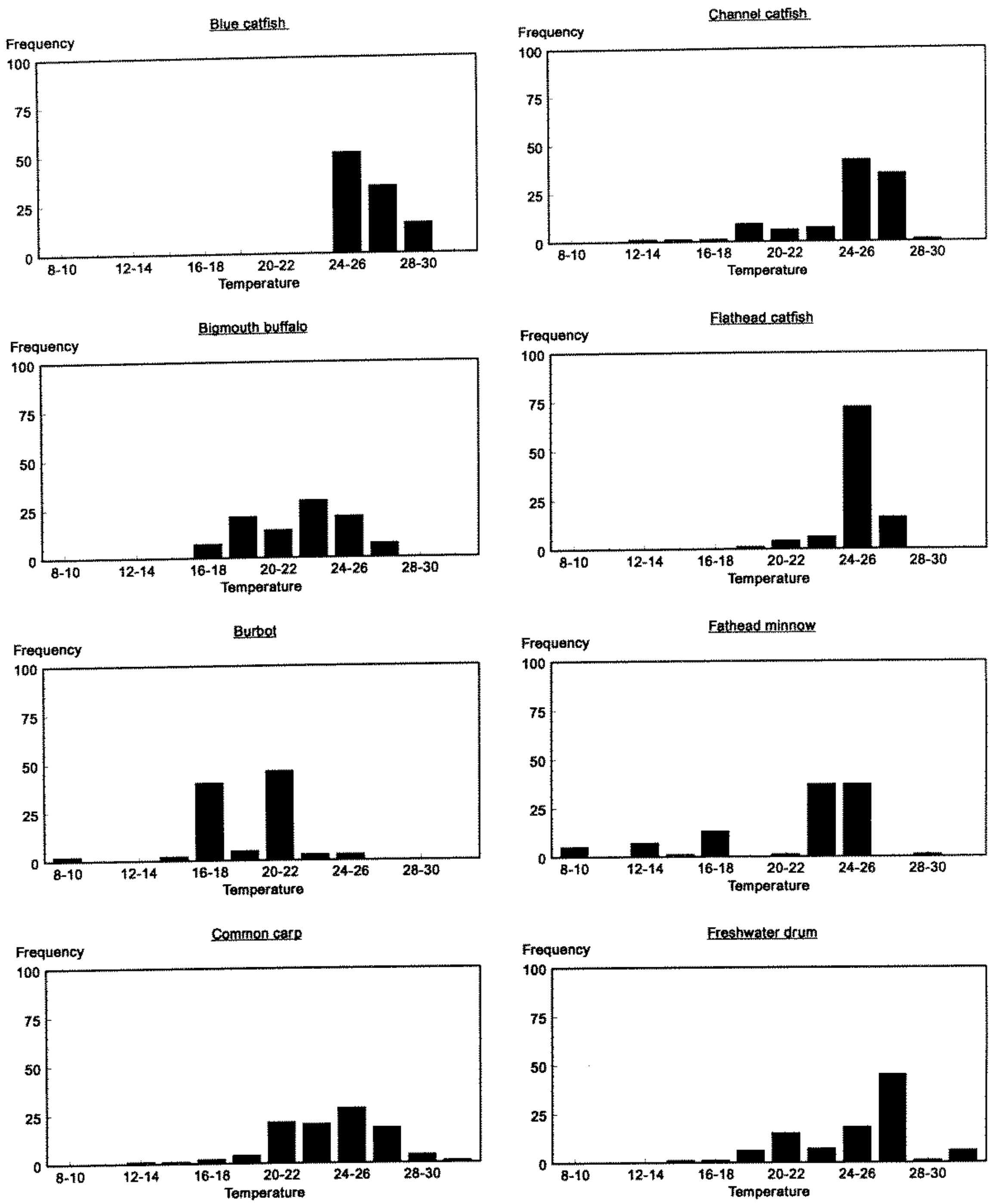
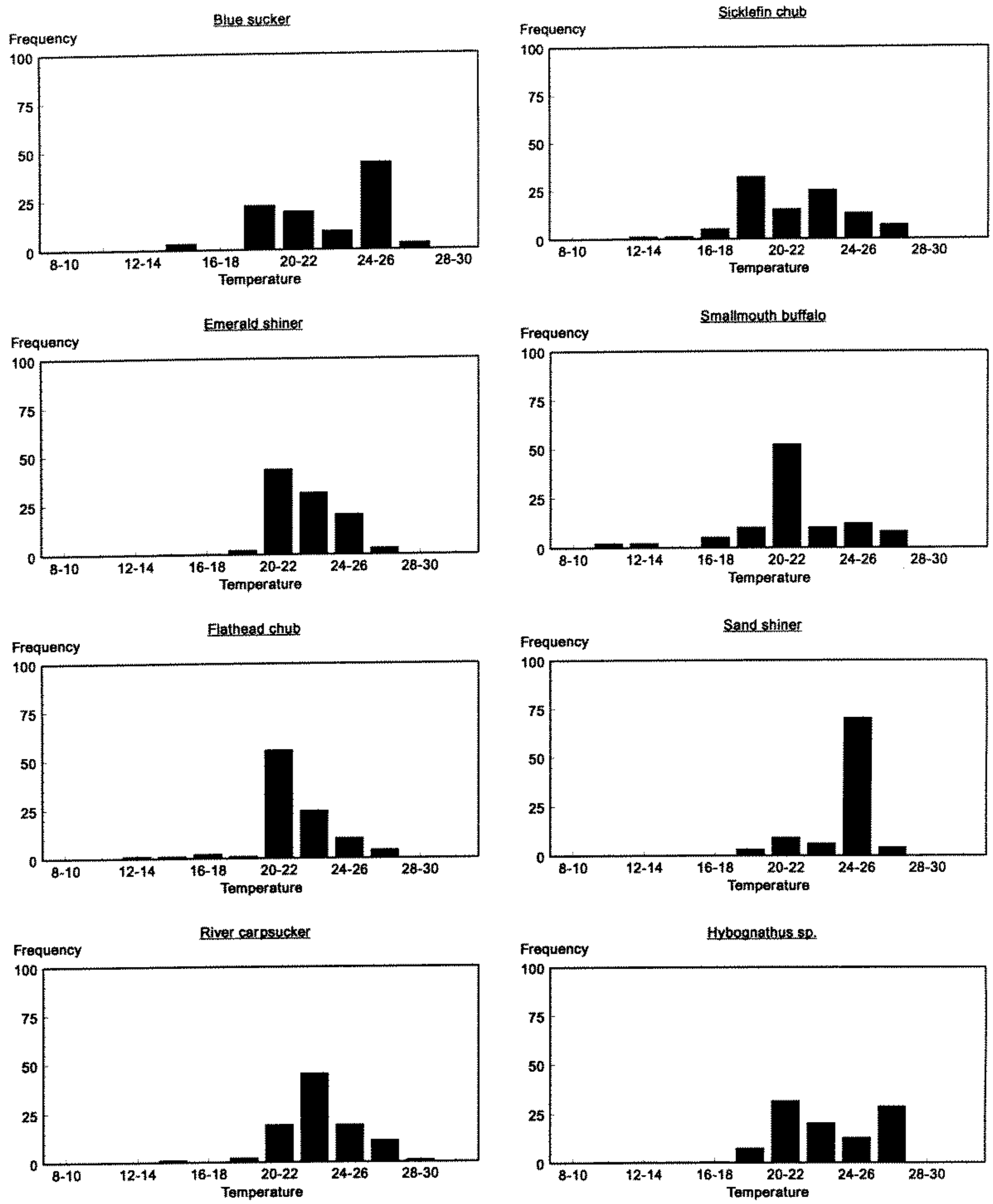


Figure 89. The frequency of occurrence of individuals of 23 Missouri and Lower Yellowstone River benthic fish taxa collected in various water temperature intervals in 1996.



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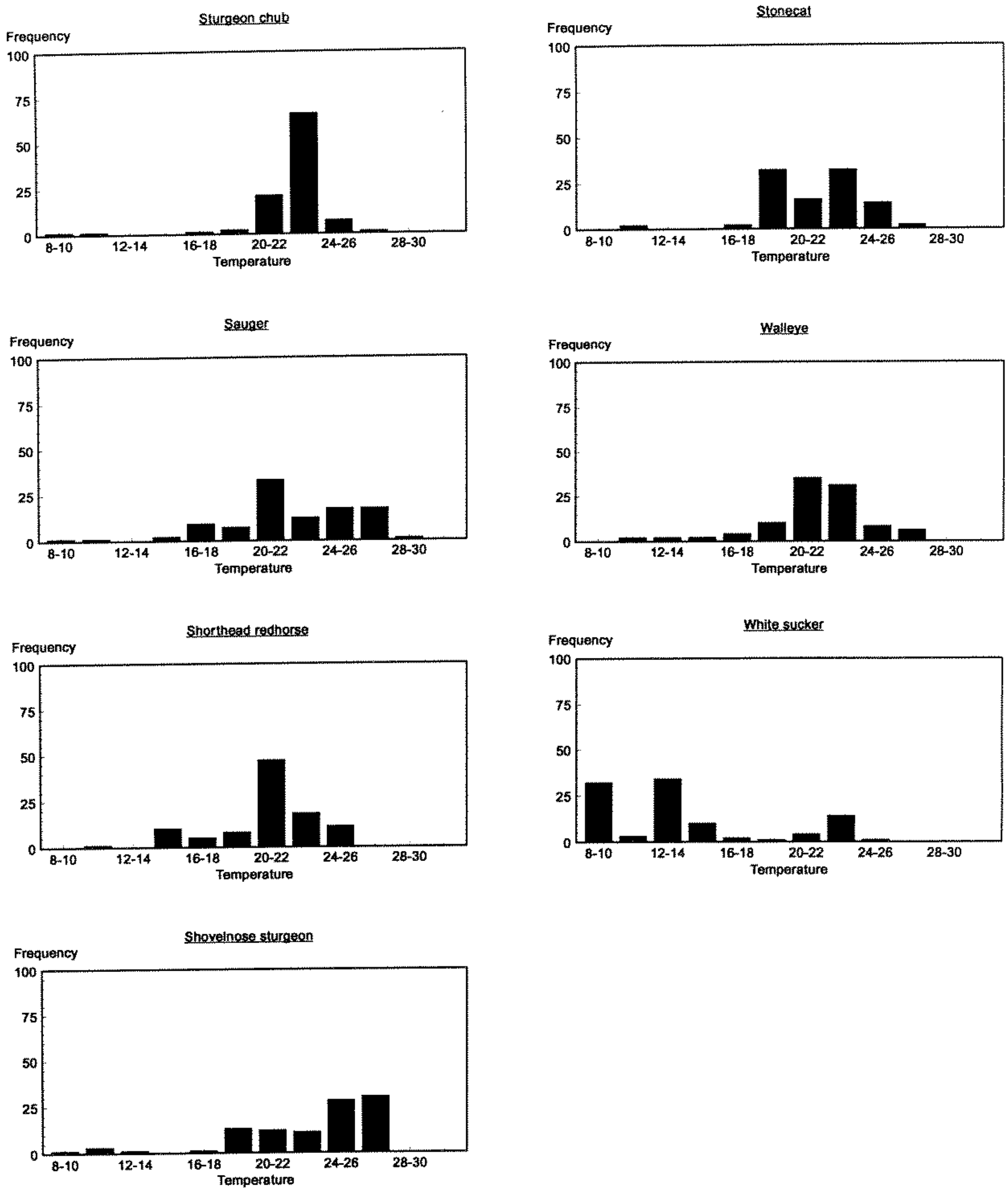

Figure 89. Continued.

Size structure

Our total sample size after only one year of collections is too small to permit final analyses at this time. However, observations which will be examined more carefully for possible trends in subsequent years include more small individuals (generally < 50 mm and likely juveniles) of channel catfish, freshwater drum, and shovelnose sturgeon in downstream segments. Also, many more larval and unidentifiable age-0 fishes were collected in upstream segments (Table 11). This may indicate that some species are spawning later in upper segments and may not be recruited to our gears at the time of sampling in Montana and North Dakota. Conversely, these species may spawn earlier in Kansas and Missouri and grow to a larger, more gear susceptible size, thus aiding capture and identification. This may suggest a later sampling season in upper segments, or not considering recruitment to our gears until fish are age-1.

Fish age and growth analyses

Age and growth information is being collected for 12 taxa (13, including flathead catfish in 1997) (Table 2). Iowa, Kansas and Idaho Units began preparing hard part body structures for age and growth analysis when field work was completed in September. Two hard body parts per fish for most taxa are used for aging purposes whenever possible to validate aging methods, which has increased processing time. However, the majority of fish and aging structures have been processed. Analysis of age structure and growth rates is continuing. Results from age and growth estimates completed to date will be presented at a June 1997 workshop. To date, structures have been received from about (i.e., not all structures have been counted yet) 235 shovelnose sturgeon, 30 smallmouth buffalo, 490 channel catfish, 80 flathead chub, 829 *Hybognathus* spp., 28 blue sucker, 470 river carpsucker, 355 freshwater drum, 103 sauger, 83 sicklefin chub, 1,277 emerald shiner, and 100 sand shiner.

Individual Section Reports

Section 1 : Missouri River Headwater Mainstem, Montana

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Montana Cooperative Fishery Research Unit

Study area. - The upper section boundary for the upper Montana Missouri River section is just upstream of the confluence of the Marias River at Loma Ferry (rkm 3303/rmi 2051). This point was chosen because it is the end of the coldwater/warmwater fisheries transitional zone (Gardner and Berg 1982). The lower boundary is Beauchamp Creek (rkm 3030/rmi 1883). This point was chosen because it is the point that in most years is the beginning of the Fort Peck slackwater and the Missouri River becomes a more lentic environment.

In the 273 km section, five distinct segments were identified (Table 60). Three of the segments (1,3, and 5) were characterized by a meandering channel with developed islands and side channels. Two of the segments (2 and 4) were characterized by relatively confined channels with little or no island or side channel development. It was concluded that insufficient time was available to accomplish our proposed sampling design for five segments under present funding and personnel commitments. It was decided that we would sample two of our five segments (one of the confined canyon segments and one of the meandering segments) and the remaining three segments would be prioritized and sampled as time and funding permitted. Sampling was conducted in segments 3, 4, and 5 during the 1996 field season. Because of sampling difficulties associated with extremely rocky substrates, segment 4 was dropped from further sampling efforts and the data from the partial sampling effort are not reported here.

SOP development. - Prior to the 1996 field season, standard operating procedures (SOPs) were developed for all fish and habitat sampling methods by the MRBFC. These SOPs were rigorously tested throughout the 1996 field season. The MTCRU was responsible for making appropriate modifications for the benthic trawl and weather SOPs. Minor modifications have been suggested for the benthic trawl SOP and will be incorporated into 1997 SOPs.

Table 60. Study segments in the upper Montana section (Section 1) of the Missouri River. Segments designated by an " * " were sampled in 1996.

Segment	Location	River-mile	Description
1	Marias River to Rattlesnake Coulee	2,053-2,2023	Meandering channel with island and side channel development
2	Rattlesnake Coulee to Arrow Creek	2,023-1,999	Confined channel with little island and side channel development
3*	Arrow Creek to Birch Creek	1,999-1,981	Meandering channel with some island and side channel development
4	Birch Creek to Sturgeon Island	1,981-1,952	Confined channel with little island and side channel development
5*	Sturgeon Island to Beauchamp Creek	1,952-1,883	Wide, meandering channel with island and side channel development

Field sampling. - Field sampling was conducted from 26 July 1996 through 20 September 1996. Eleven physicochemical variables were measured following SOP's in conjunction with fish sampling to identify habitat use within macrohabitats and among study segments. A summary of selected variables is presented in Table 61.

Thirty species of fish were captured in 1996 (this number may be as high as 32 when positive identification is completed on *Hybognathus* spp.). Catch rates of all species are given in Table 62. Of these, 20 were target benthic taxa (this number may be as high as 22 when positive identification is completed on *Hybognathus* spp.). The only target species we are certain that we did not sample during 1996 were pallid sturgeon and sand shiner. Pallid sturgeon are an endangered species with few individuals remaining and sand shiner are rare in this area. Total catch for non-target species is given in Table 63. Scale, spine, ray, and/or otolith samples were collected and sent to Iowa, Kansas, and Idaho Units on $\geq$ 50 fish for 11 of 24 taxa to determine age and growth.

Meetings/presentations. - A MRBFC workshop was held 21-22 June 1996 in Omaha, NE prior to the 1996 field season. Topics covered included project overview, oral progress reports from all units, temporal sampling schedule, SOPs and Ph.D. topics. Lee Bergstedt presented an outline of his Ph.D. research topic, "Fish communities as indicators of environmental degradation on the Missouri River" A second MRBFC workshop was held 21-23 November 1996 in Omaha, NE at the conclusion of the field season. Topics included oral progress reports, research work order administration, statistical analyses, and SOP revisions.

Table 61. Mean values for selected physicochemical variables in segments 3 and 5 by macro- and meso-habitat on the upper Missouri River (Section 1) in Montana, 1996.

Segment	Habitat	Conductivity (umho/cm)	Turbidity (NTU's)	Temp. (^{o}C)	Depth (m)	Velocity (m/s)	% gravel	% sand	% silt
3	CHXO	398.46	28.81	21.64	1.7	1.005	61.3	38.7	0.0
	ISB-BARS	567.08	395.90	21.32	0.37	0.263	43.5	2.5	54.0
	ISB-CHNB	396.66	45.96	21.68	1.75	0.840	53.9	46.1	0.0
	OSB	398.12	19.38	21.30	1.48	0.626	45.6	48.4	6.0
	SCC-SHLW	399.69	24.65	21.20	0.36	0.580	64.4	16.7	18.9
5	CHXO	405.18	13.19	22.07	2.46	0.595	25.6	73.3	1.1
	ISB-BARS	416.31	17.30	21.69	0.53	0.435	14.0	58.5	27.5
	ISB-CHNB	407.15	13.26	22.25	1.61	0.775	20.5	79.5	0.0
	ISB-STPS	424.81	68.96	16.98	1.35	0.543	35.0	65.0	0.0
	OSB	415.48	12.23	22.37	2.02	0.621	33.6	55.5	10.9
	SCC-DEEP	397.84	14.71	21.65	1.75	0.382	22.5	38.5	39.0
	SCC-SHLW	429.30	25.10	22.40	0.40	0.517	30.0	15.0	55.0
	SCN	487.05	54.80	23.90	0.75	0.000	0.0	0.0	100.0

Table 62. Catch rates and total catch of all species by segment, macro- and meso-habitat, and gear in segments 3 and 5 in Upper Missouri River study section 1 in Montana, 1996.

Segment	Habitat	Taxa	BS	BT	DTN	EF	SGN-	Total
3	CHXO	GDEY			0.2			3
		SNSG			0.1			1
	ISB-BARS	ERSN	1.9					19
		FHCB	112.7					1127
		FHMW	0.1					1
		HBNS	9.5					95
		LKCB	0.1					1
		LNDC	0.4					4
		NTPK	0.1					1
		RVCS	0.9					9
		SHRH	1.5					15
		SMBF	1.9					19
		STCT	0.2					2
		STSN	0.5					5
		U-BF	1.5					15
		U-CT	7.1					71
		U-CY	0.3					3
		WTSK	1.3					13
	ISB-CHNB	GDEY			0.3			5
		SNSG			0.1			1
	OSB	BRBT				0.0		1
		BUSK			0.1	0.0		2
		CARP				0.2		14

Table 62. Continued.

Segment	Habitat	Taxa	BS	BT	DTN	EF	SGN-	Total
3	OSB	CNCF				0.1		6
		ERSN				0.6		48
		FHCB				0.21		16
		FWDM				0.3		19
		GDEY			0.3	0.2		16
		HBNS				0.1		5
		LNDC				0.1		6
		LNSK				0.0		3
		MDSP				0.0		1
		NTPK				0.1		5
		RVCS				0.1		4
		SGER				0.1		6
		SHRH				0.8		58
		STCT				0.0		1
		STSN				0.36		27
		U-CT				0.1		5
		U-ST				0.0		2
		WTCP				0.0		1
	SCC-SHLW	ERSN	1.1					11
		FHCB	19.4					194
		HBNS	0.2					2
		LNDC	2.4					24
		LNSK	0.2					2
		NTPK	0.2					2

Table 62. Continued.

Segment	Habitat	Taxa	BS	BT	DTN	EF	SGN-	Total
3	SCC-SHLW	RVCS	0.1					1
		SHRH	0.9					9
		SMBF	0.3					3
		STSN	0.4					4
		U-CT	3.7					37
		WTCP	1.4					14
		WTSK	2.2					22
5	CHXO	BRBT			0.1			1
		FHCB		0.1	0.1			3
		GDEY			0.1			2
		LNDC		0.1				1
		SFCB		0.7				11
		SGCB		0.3				4
		SGER		0.1	0.1			1
		SNSG		0.3	0.3			5
		U-CY		1.1				16
	ISB-BARS	ERSN	5.8					58
		FHCB	4.1					41
		HBNS	37.4					374
		NTPK	0.1					1
		STSN	2.1					21
		WLYE	0.1					1
		YOYF	0.5					5

Table 62. Continued.

Segment	Habitat	Taxa	BS	BT	DTN	EF	SGN-	Total
5	ISB-CHNB	BRBT		0.1				1
		FHCB		0.4	0.1			7
		GDEY			0.3			5
		LNDC		0.3				5
		SFCB		0.6				8
		SGCB		0.8				12
		SHRH		0.1	0.1			2
		SNSG			0.1			2
		U-CY		0.3				4
	ISB-STPS	BKCP				0.1		7
		BRBT				0.3		21
		CARP				0.1		6
		CNCF				0.0		1
		ERSN				0.5		43
		FHCB				0.5		38
		FWDM				0.2		17
		GDEY				0.1		11
		HBNS				0.2		13
		LNSK				0.0		1
		NTPK				0.1		5
		RVCS				0.1		4
		SGCB				0.0		1
		SGER				0.1		10
		SHRH				0.4		29

Table 62. Continued.

Segment	Habitat	Taxa	BS	BT	DTN	EF	SGN-	Total
5	ISB-STPS	STCT				0.0		1
		STSN				0.3		20
		U-ST				0.1		6
		WLYE				0.0		2
		WTCP				0.0		2
		YWPH				0.3		21
	OSB	BKCP			0.1	0.1		9
		BRBT				0.1		8
		BUSK				0.0		2
		CARP				0.1		11
		CNCF		0.1		0.1		11
		ERSN				0.1		14
		FHCB		0.1	0.3	0.3		14
		FWDM				0.2		14
		GDEY			0.2	0.1		12
		HBNS				0.0		1
		LNDC		0.3		0.0		5
		MDSP				0.0		1
		NTPK				0.0		3
		RVCS				0.0		2
		SFCB		0.1				1
		SGCB		0.8				12
		SGER				0.0		3
		SHRH				0.2		13

Table 62. Continued.

Segment	Habitat	Taxa	BS	BT	DTN	EF	SGN-	Total
5	OSB	SMBF				0.0		1
		SNSG			0.2			3
		STSN				0.5		32
		U-CY			0.2	0.0		3
		U-ST				0.0		1
		WLYE			0.1	0.0		2
		WTCP				0.1		4
		YEPH				0.1		11
	SCC-DEEP	BMBF	0.25					1
		BRBT		0.1				1
		CNCF		0.1	0.1			2
		ERSN	30.5					122
		FHCB	3.25	0.1	0.2			16
		GDEY		0.3				3
		HBNS	0.5	0.1				3
		LNDC		0.4				4
		NTPK	0.8					3
		SFCB		0.1				1
		SGCB		1.3				14
		SGER			0.2			2
		SNSG		0.1	0.1			2
		STSN	1.25	0.2				7
		U-CT	0.5					2
		U-CY		0.1				1

Table 62. Continued.

Segment	Habitat	Taxa	BS	BT	DTN	EF	SGN-	Total
5	SCC-DEEP	UNID	0.8	0.36				7
		YWPH	0.3					1
	SCC-SHLW	FHCB	1.0					2
	SCN	BKCP	0.3					1
		CARP					0.8	5
		CNCF					1.5	9
		ERSN	18.0					72
		GDEY					0.2	1
		HBNS	0.5					2
		NTPK	0.3				0.5	4
		RVCS					0.3	2
		SMBF					0.3	2
		WTCP	1.0				0.2	5

Table 63. Total catch for non-target species in segments 3 and 5 in Upper Missouri River study section 1 in Montana, 1996.

Species	Segment 3	Segment 5
Goldeye	24	34
Lake chub	1	0
Spottail shiner	36	86
Longnose dace	34	15
Longnose sucker	5	1
Northern pike	8	16
Mottled sculpin	1	1
White crappie	15	11
Black crappie	0	17
Yellow perch	0	33

Sections 2 and 3: Upper Inter-Reservoir I and Lower Yellowstone River, Montana

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Study area. - Montana Fish, Wildlife and Parks (MTFWP) study area is the Missouri River below Fort Peck Dam (rkm 2850/rmi 1770) to the Yellowstone River confluence (rkm 2546/rmi 1581) in North Dakota, and the Yellowstone River from Intake Diversion Dam (rkm 114/rmi 71) to its confluence with the Missouri River, for a total study length of about 418 km. Numbering of sections and segments was coordinated with the MRBFC. The Missouri River in Montana was divided into three segments **6**, **7**, and **8** within one section numbered **2**. The Yellowstone River was not divided and assigned section number 3, segment number 9.

Section **2** segment **6** is a unique area as a result of Fort Peck Dam construction and operation. Segment **6** originates below the dam and extends to the Milk River mouth (rkm 2832/rmi 1759), an approximate distance of 18 km. The dam discharges cold, clear, hypolimnetic water. Substrate is dominated by gravel and sand. The dam was formed with dredged material from the river below the dam. The dredged pools became large backwaters. These "dredge cuts" provide recreational opportunities for boating and fishing. The spillway enters the river about 16 km below the dam and operated in 1996. The spillway resembled a small tributary adding warm water and turbidity to the hypolimnetic waters of the tailrace. Municipal and agricultural water use occurs in this segment.

Section **2** segment **7** is entirely riverine but strongly influenced by hypolimnetic dam discharge. Segment **7** starts at the Milk River confluence and ends at Montana Highway 13 bridge (rkm 2737/rmi 1670) near Wolf Point, Montana, an approximate distance of 95 km. Milk River discharge has the ability to increase turbidity and moderately warm Missouri River water in this segment. Gravel and sand substrates are common with two cobble rapids. Segment **7** supports irrigation, municipal use, and limited recreational use. Sand, Little Porcupine, and Wolf Creeks are all intermittent streams that enter this segment. The Fort Peck Indian Reservation borders the north bank of the river from the Milk River confluence to the Big Muddy River mouth in Segment **8**.

Section **2** segment **8** is riverine with greater turbidity and warmer summer temperatures than segment 7. Segment **8** starts at Montana Highway 13 bridge and ends at the Yellowstone River confluence (rkm 2546/rmi 1581), an approximate distance of 191 km. The river becomes depositional with greater sandbar development than in segments **6** and 7. Sand dominates the substrate. Several small tributaries contribute warm water and higher turbidity. Tributaries include the Redwater, Poplar, and Big Muddy rivers, and several intermittent streams. Irrigation dominates water use with municipal and recreational use following.

Section 3 segment 9, the Yellowstone River below Intake Diversion represents a river without a major mainstem dam controlling flow, temperature or turbidity. Segment 9 is 114 km long. Substrates in the upper portion are dominated by gravel and sand dominates below Sidney, MT. This segment has agricultural and municipal use and much greater recreational use than segments **7** and **8**.

Standard operating procedures. - Standard operating procedures were developed by the MRBFC in 1996 and tested before actual data collection. MTFWP was responsible for creation of the drift trammel net standard operating procedure. Few changes were suggested at the MRBFC June workshop, so few modifications were necessary. At the November workshop group consensus was to extend sampling time for trammel nets already in the water. Thus, distance was no longer standardized, but total length drifted will be noted on data sheets.

Field sampling. - During the 1996 field season the benthic fish study borrowed a boat and shared field personnel from the pallid sturgeon research group. In return the benthic fish study loaned the pallid sturgeon work group the benthic fish boat and field personnel to complete their field season and laboratory larval sample sorting. Three boats were shared between the two research groups which required us to share resources. A fourth boat has been secured for the 1997 field season without charge from Montana Fish, Wildlife and Parks personnel in Fort Peck. This polar craft will be used as the habitat boat. Since field personnel were shared, training seemed to be a continuous effort. Several field technicians returned to school or found permanent work. This required both studies to hire additional personnel which required training late in the field season.

Gear design and implementation followed 1996 MRBFC standard operation procedures. Electrofishing was not used in section **2** or 3. Endangered pallid sturgeon are present in both sections. Potential injury to pallid sturgeon prohibits the use of electrofishing in suspected pallid sturgeon locations.

Field sampling began July 17th and ended October 28th for a total of 31 field days. Segment **6** was sampled July 17, August 20, 21, and 22. Segment **7** was sampled July 18, and 19, August 6, October 11, 17, 24, 25, and 28. Segment **8** was sampled July 30, 31 August 1, 2, 7, September 11, 12, 27, and 30. Segment 9 was sampled August 8, 9, 13, 14, 15, 16, 26, 27, 28, 29.

Eight macro- and meso-habitat types were sampled in 1996. Equal sampling of macro- and meso-habitats throughout all segments was not attained due to lack of habitats or time (Table 8). Macro- and meso-habitats not common or unavailable in sections **2** and 3 and not sampled were TRM-LRGE and ISB-POOLS. ISB-STPS mesohabitats were not sampled in sections **2** and 3 because electrofishing was the only gear used to sample them. Sampling in segment 9 was nearly complete. Segment 9 lacked tributaries large enough to sample. Low river stage prohibited completion of the fifth ISB-CHNB replicate. The Yellowstone River stage dropped quickly in August leaving only two of five ramps useable. The Confluence and Intake ramps were accessible throughout the sampling period. Sampling in segment **8** was complete. Three TRM-SMLL were sampled as well as five replicates of each remaining macrohabitat. Sampling in segment **7** was nearly completed. All continuous macrohabitats (i.e., CHXO, OSB, ISB) were sampled. Three ISB-BARS and SCCs were sampled. The remaining two ISB-BARS and SCCs were not sampled due to cold weather. Two SCN were sampled. Segment **7** lacked available backwater due to increased discharge from Fort Peck. Four TRM-SMLL were sampled. Segment **6** sampling was limited. This segment does not represent a riverine area due to dredge cuts. All SCNs sampled were dredge cuts created during dam construction. All SCC macrohabitats were sampled. One

TRM-SMLL, the Milk River, was sampled. The spillway discharged water during the summer of 1996, and was treated as a TRM-SMLL during sampling.

Physicochemical variables were measured at each fish collection location. Locations were documented with GPS units. Nearly all measurements followed SOPs outlined in Sappington et al. (1996). Exceptions were noted on data sheets. Drifting trammel net and benthic trawl samples were normally taken at the same location within four hours of each other. Physicochemical measurements were occasionally taken only once in the location but the data used on both benthic trawl and drifting trammel net habitat data sheets. A summary of physicochemical measurements is provided in the basin wide annual report.

Twenty six benthic fish taxa are targeted by the MRBFC with twenty one of those captured in sections **2** and 3 combined (Table 64). Pallid sturgeon, sand shiners, and brassy minnows are targeted species which were not captured but have been documented in these study sections. Flathead catfish and blue catfish were not captured as this study area is outside their range. The 1996 system-wide report contains catch rate and size structure information for all target species.

Non-target taxa captured in sections **2** and 3 were green sunfish, longnose sucker, longnose dace, goldeye, white crappie, creek chub, northern pike, spottail shiner, yellow perch, cisco, rainbow trout, rainbow smelt, smallmouth bass, northern redbelly dace, unidentified-cyprinids, unidentified-catostomids, unidentified-buffalo species, unidentified-*stizostedion*, larval fish, and young-of-year fish (Table 65). Goldeye were commonly captured in all segments. In segment **6**, 119 spottail shiners were captured. Spottail shiners were captured in the warmer dredge cuts with only a small number large enough to be captured with the bag seine. Many hundred were too small to capture in the seine but could be seen pouring out as the seine was brought to the banks. Six rainbow trout young-of-year were captured in SCC in segment **6**. Those specimens were sent to the disease lab to be tested for whirling disease. A smallmouth bass young-of-year was captured in dredge cuts in segment **6**. Fifty eight crappie were captured in segments **7**, **8**, and 9 combined. Crappie were listed as rare by Gardner and Stewart (1987). Liebelt (1996) sampled this study area in

Table 64. Total numbers of target benthic taxa collected in Missouri River study section **2** (segments **6,7, 8**) and Lower Yellowstone section 3 (segment 9) in 1996.

Species	Section / Segment	3 / 9	**2** / **8**	**2** / **7**	**2** / **6**	**2** / All	Total
Pallid sturgeon		0	0	0	0	0	0
Shovelnose sturgeon		28	4	9	3	16	44
Common carp		7	5	1	0	6	13
Flathead chub		1189	67	5	0	72	1261
Sicklefin chub		6	6	0	0	6	12
Sturgeon chub		230	37	5	0	42	272
Emerald shiner		11	0	0	0	0	11
Hybognathus spp.		359	5	0	0	5	365
Blue sucker		2	0	0	1	1	3
Bigmouth buffalo		1	0	0	0	0	1
Smallmouth buffalo		4	3	0	1	4	8
River carpsucker		279	12	6	2	20	299
White sucker		0	93	103	19	225	225
Shorthead redhorse		2	5	0	1	6	8
Channel catfish		83	3	0	1	4	87
Stonecat		22	0	1	0	1	23
Burbot		0	2	1	0	3	3
Sauger		8	1	3	0	4	12
Walleye		1	2	0	2	4	5
Freshwater drum		9	4	0	0	4	13
Fathead minnow		0	5	10	2	17	17
Flathead catfish		0	0	0	0	0	0
Blue catfish		0	0	0	0	0	0

Table 65. Total numbers of non-target taxa collected in Missouri River study sections **2** (segments **6,7, 8**) and 3 (segment 9) in 1996.

Species	Section / Segment	3 / 9	**2** / **8**	**2** / **7**	**2** / **6**	**2** / All	Total
Green sunfish		4	0	0	0	0	4
Longnose sucker		3	10	4	8	22	25
Longnose dace		38	1	5	0	6	44
Goldeye		41	100	25	13	138	179
White crappie		20	37	1	0	38	58
Creek chub		3	0	0	0	0	3
Northern pike		6	14	6	10	30	36
Spottail shiner		0	4	4	119	127	127
Yellow perch		0	2	0	0	2	2
Cisco		0	0	0	11	11	11
Rainbow trout		0	0	0	6	6	6
Smallmouth bass		0	0	0	1	1	1
Rainbow smelt		0	0	0	1	1	1
Northern redbelly dace		0	0	1	0	1	1
U-cyprinid		185	5	1	5	11	196
U-catastomid		337	4	4	2	10	347
U-buffalo		2	0	0	0	0	2
Young of year fish		380	9	0	0	9	389
Larval fish		0	0	5	0	5	5
Unidentified		3	0	12	0	12	17
U-*stizostedion*		0	1	0	0	1	1

U-represents unidentified to species.

1994 and 1995 and didn't capture a single specimen. Two yellow perch were captured in segment **8**, both young-of-year. Unidentifiable minnows, suckers, young-of-year fish, larval fish, *stizostedion*, and buffalo become more prevalent as distance increases away from Fort Peck Dam. An additional observation was the presence of two sturgeon chubs in the stomach of a sauger collected in the Lower Yellowstone River. Other sauger stomachs examined had unidentifiable fish and insects or were empty.

Meetings/presentations. - Presentations were given at MRBFC workshops, the pallid sturgeon workgroup meeting in Miles City, MT in December, and the Bureau of Reclamation DSS meeting in Billings, MT in November.

Miscellaneous activities. - Additional activities were conducted during the 1996 field season. Aquatic insects were collected by kick sampling and trawling. Collections supplemented invertebrate studies from 1994 and 1995. Identification hasn't been completed for all specimens. Location of mussel beds were documented and representative specimens collected. Dr. Daniel Gustafson of Montana State University-Bozeman identified the specimens to species and has included them in distributions of mussels in Montana. We assisted the pallid sturgeon working group in collecting brood fish in September and October. All sturgeon and blue sucker captured were spaghetti tagged using the same procedures as the Fort Peck pallid sturgeon research group.

Acknowledgements. - Many thanks go to the Montana field crew which included Dave Fuller, Jim Schultz, Matt Baxter, Sue Ireland, Cameron Shipp, Shawn Goodchild, and William Walker.

Sections 4 and 5 : Upper Inter-Reservoir II, North Dakota

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Study area. - North Dakota contains two sections of the Missouri River within state boundaries, sections **4** and **5** (Figure 90). Section **4** extends from the Yellowstone-Missouri River confluence (rkm 2548/rmi 1582) to its lower boundary of Lake Sakakawea (rkm 2472/rmi 1535). Section **5** extends from Garrison Dam (rkm 2237/rmi 1389) to its lower boundary of Lake Oahe (rkm 2053/rmi 1275).

Section **4** still exhibits many pre-impoundment physical and biological characteristics. Physical characteristics include a shallow and braided channel, high sediment load, and fluctuating hydrograph characterized by a March and June rise. The Yellowstone River contributes large amounts of sediment and organic matter. This section also retains most of the fish species native to the Missouri River.

Section **5**, in contrast, exhibits fewer pre-impoundment physical and biological characteristics. Garrison Dam and Lake Sakakawea have created an alluvium sink, thereby reducing sediment load in the river below the dam (Berkas 1995). Water is uncharacteristically clear and natural aggredative and degredative processes have been disrupted. Furthermore, the dam regulates the hydrograph and has created an unnatural temperature regime characterized by cool water during summer months. Other major channel modifications in this section, include placement of rip-rap and wingdams.

We divided section **4** into segments **10** (Yellowstone-Missouri River confluence - Lake Sakakawea headwaters) and **11** (Lake Sakakawea headwaters - Lake Sakakawea) and divided section **5** into segments **12** (Garrison Dam - Lake Oahe headwaters) and **13** (Lake Oahe headwaters - Lake Oahe). In 1996, fish were sampled only from segments **10** and **12** (riverine segments).

Standard operating procedures. - The Idaho Coop Unit was responsible for the time SOP. No modifications were suggested at 1996 workshops, so no additional work was necessary.

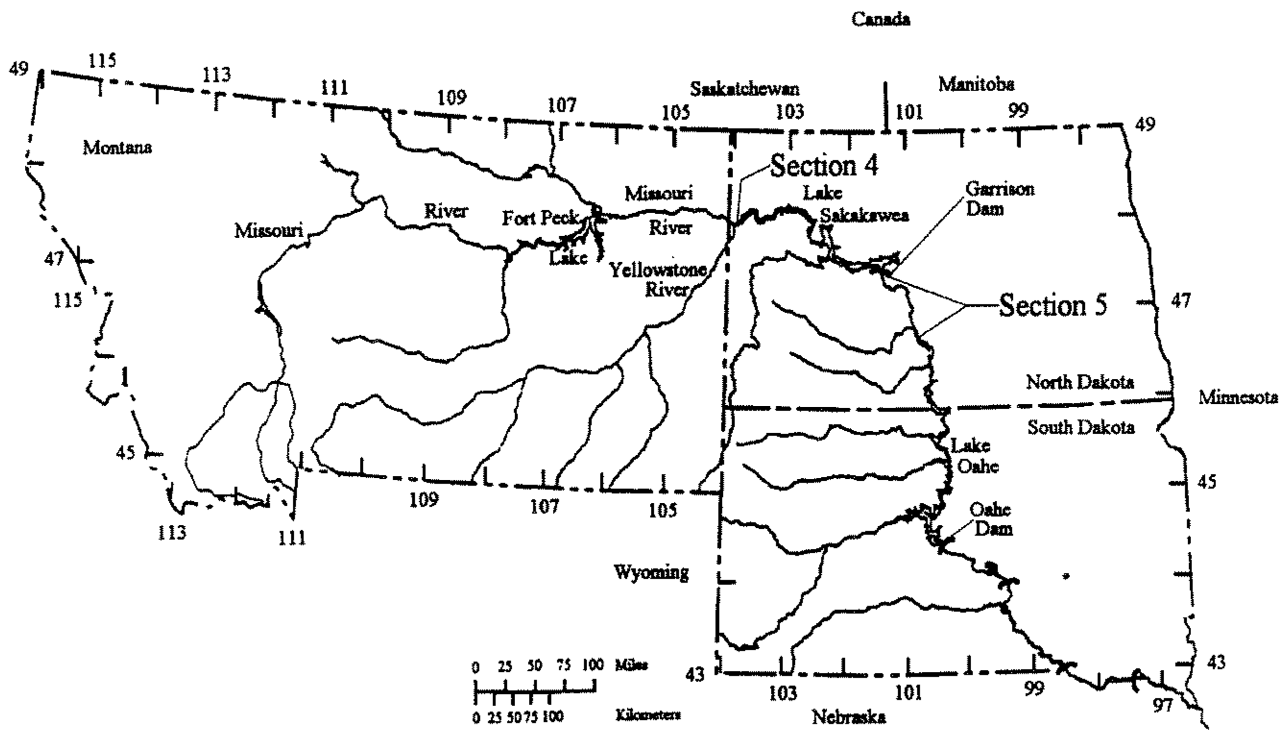

Figure 90. Missouri River study sections in North Dakota.

Preliminary/additional sampling. - Segment **10** (Yellowstone River-Lake Sakakawea headwaters) contains two oxbow lakes that connect with the mainstem Missouri River each spring. One oxbow, Erickson Island area, maintained a connection with the mainstem through August via a narrow channel. This channel was sampled at its mouth with a gill net but could not be seined effectively because of a silt bottom. The gill net (3 hour set) yielded 9 northern pike, 2 channel catfish, 1 bigmouth buffalo, 1 smallmouth buffalo, 1 goldeye, and 1 black crappie.

We conducted exploratory electrofishing in this channel in August. Approximately twenty-five minutes of electrofishing yielded the following species: bigmouth buffalo, smallmouth buffalo, river carpsucker, common carp, freshwater drum, emerald shiner, northern pike, and white crappie. Many large bigmouth buffalo, smallmouth buffalo, and river carpsucker were captured.

In segment **10**, several gill nets were set in SCC that were too deep to seine and too narrow to drift a trammel net. We found that gill nets were an ineffective fish sampling method in these areas. Large amounts of organic material clogged the mesh of the gill net after only a three hour set.

Field sampling. - We ordered equipment in May 1996 and had received and calibrated it, and tested field methods by mid-July. Three field technicians were trained in field sampling techniques for two weeks in early-July. We began sampling segment **12** macrohabitats in late July. We rotated sampling effort weekly between segment **10** and segment **12** from July 23 to September 19. The MRBFC determined that segment rotation would prevent oversampling a segment early in the season and in turn increase young-of-year (YOY) recruitment to gears.

In segment **10** we sampled five ISB, OSB, SCC, and CHXO macrohabitats. Only four SCNs were sampled. No TRM were sampled in this segment. In all, 471 fish were captured representing 24 species and 10 families. Target benthic fish constituted 63% (299 individuals) of the total catch (target and non-target fish combined) with a species richness of 17 (Table 66) and a family richness of 7 (Acipenseridae, Catostomidae, Cyprinidae, Gadidae, Ictaluridae, Percidae, Sciaenidae). The most commonly captured target fish was flathead

Table 66. Target taxa and numbers captured in Missouri River study segment **10** in 1996.

Taxa	CHXO	OSB	ISB	SCC	SCN	Total	% of Target
	Macrohabitats						
Flathead chub		4	53	68		125	42
Burbot		28	1			29	10
Channel catfish	14	10		2	3	29	10
Sicklefin chub	12	9	1	6		28	9
Shovelnose sturgeon	12	8	1	3		24	8
Stonecat		13		1		14	5
Freshwater drum		1			11	12	4
Sturgeon chub	1	4	4	2		11	4
Sauger		3	1	2	1	7	2
Smallmouth buffalo		1			3	4	1
Bigmouth Buffalo			2		1	3	1
Shorthead redhorse		2	1			3	1
Hybognathus spp.		1		2		3	1
River carpsucker				1	1	2	<1
Emerald shiner					2	2	<1
White sucker				2		2	<1
Blue sucker		1				1	<1
Total catch	39	85	64	89	22	**299**	
Species richness	4	13	8	10	7	**17**	
% of total target	13	28	21	30	7		

chub. Burbot, channel catfish, sicklefin chub, and shovelnose sturgeon also were captured frequently. Outside bend and SCC macrohabitats yielded the most target fish, 89 and 85, respectively. The fewest target fish were captured in SCN (22) and CHXO (39) macrohabitats. Highest species richness was found in the OSB macrohabitat (13) and the lowest in the CHXO (4) macrohabitat (Table 66).

Twelve species of fish were captured in three macro- and meso-habitats in the bag seine (Table 67). Highest species richness was found in SCC-SHLW (7) and the lowest in SCN (3). The most commonly captured fish was flathead chub in ISB-BARS (53) and SCC-SHLW (63). Freshwater drum was the second most frequently captured fish (11) and was captured exclusively in SCN. Highest CPUE (fish/m^2) was flathead chub in ISB-BARS (0.07) and SCC-SHLW (0.06).

Seven species were captured in four macro- and meso-habitats in the benthic trawl (Table 67). Highest species richness was found in OSB(7) and the lowest in ISB-CHNB (2). The most commonly captured fish, sicklefin chub and channel catfish, were found in CHXO and OSB (Table 66). Highest CPUE (fish/100 m trawled) was sicklefin chub (1.0) in SCC-DEEP and channel catfish (0.9) in CHXO.

Three species were captured in four macro- and meso-habitats in trammel nets (Table 67). Highest species richness, two, was found in three macro- and meso-habitats (CHXO, ISB-CHNB, SCC-DEEP). The most commonly captured target fish, shovelnose sturgeon (16), was found most frequently in CHXO (10) and OSB (4). Highest CPUE (fish/100 m drifted) was for shovelnose sturgeon (0.7) in CHXO.

Seven species of target benthic fish were captured by electrofishing in one macrohabitat (OSB) (Table 67). Burbot was the most commonly captured fish (29) and had the highest CPUE (0.4 fish/100 m).

Four species of fish were captured with gill nets in one macrohabitat (SCN) (Table 67). The most commonly captured fish were smallmouth buffalo (3) and channel catfish (3). Catch-per-unit-effort (fish/hour) for channel catfish and smallmouth buffalo was 0.3.

One hundred and seventy-two non-target fish were captured (Table 68) representing seven species and four families (Centrarchidae, Cyprinidae, Esocidae, Hiodontidae) in

Table 67. Target taxa and numbers captured in Missouri River study segment **10** by gear and macro- and meso-habitat combination in 1996. A "-" means no fish were collected in that habitat. A blank space means the gear was not used in that habitat.

Taxa	CHXO	OSB	ISB-BARS	ISB-CHNB	SCC-DEEP	SCC-SHLW	SCN	TOTAL
			Bag Seine (16 hauls)					
Flathead chub			53			63	-	116
Sturgeon chub			-			1	-	1
Hybognathus spp.			-			2	-	2
Emerald shiner			-			-	2	2
Freshwater drum			-			-	11	11
Sauger			-			2	1	3
River carpsucker			-			1	-	1
White sucker			-			2	-	2
Bigmouth buffalo			2			-	-	2
Shorthead redhorse			1			-	-	1
Burbot			1			-	-	1
Channel catfish			-			1	-	1
								143
			Benthic Trawl (26 tows)					
Sicklefin chub	11	10		1	6			28
Sturgeon chub	1	4		4	1			10
Shovelnose sturgeon	5	3		-	2			10
Blue sucker	-	1		-	-			1
Channel catfish	13	10		-	-			23
Stonecat	-	12		-	1			13
Burbot	-	1		-	-			1
								86
			Drifting Trammel Nets (26 drifts)					
Shovelnose sturgeon	10	4		1	1			16
Channel catfish	1	-		-	1			2
Sauger	-	-		1	-			1
								19
			Boat Electrofishing (15 runs for a total time of 75 minutes)					
Flathead chub		4						4
Hybognathus sp.		1						1
Freshwater drum		1						1
Sauger		1						1
Shorthead redhorse		2						2
Smallmouth buffalo		1						1
Burbot		29						29
								39

Table 67. Continued.

Taxa	CHXO	OSB	ISB-BARS	ISB-CHNB	SCC-DEEP	SCC-SHLW	SCN	TOTAL
Stationary gill nets (3 sets for a total time of 9 hours)								
River carpsucker							1	1
Bigmouth buffalo							1	1
Smallmouth buffalo							3	3
Channel catfish							3	3
								8

Table 68. Non-target taxa and numbers captured in Missouri River study segment **10** in 1996.

Taxa	CHXO	OSB	ISB	SCC	SCN	Total	% of Target
	Macrohabitats						
White crappie					60	60	13
Goldeye		12	8	6	8	34	7
Northern pike				3	28	31	7
Unidentified minnow			12	1		13	3
Unidentified *Stizostedion*		3	2	3	2	10	2
Unidentified sucker				2	8	10	2
Common carp	1	2			6	9	2
Black crappie					3	3	1
Longnose sucker		1				1	<1
Green sunfish		1				1	<1
Total catch	1	19	22	15	115	**172**	
Species richness	1	5	3	5	7	7	

segment **10**. The most commonly captured non-target fish were white crappie (60), goldeye (34), and northern pike (31). SCN contained the highest number of non-target fish (115) and CHXO the lowest (1).

In segment **12** five CHXO, SCC, and SCN macrohabitats were sampled, as were four OSB, ISB, and TRMs. Also, the Garrison Dam tailrace (wild macrohabitat; WILD) was sampled. One-thousand-thirty-four fish were captured representing 27 species and 11 families. Target benthic fish constituted 39% (406 individuals) of the total catch (target and non-target fish combined) with a species richness of 10 (Table 69) and a family richness of 4 (Catostomidae, Cyprinidae, Ictaluridae, Percidae). The fathead minnow was the most commonly captured target species (221) followed by white sucker (139). These two species constituted 34% of the total catch.

The SCN macrohabitat yielded the most target fish (237) and CHXO the fewest (0) (Table 69). Highest target species richness was obtained from the TRM (8) and lowest from CHXOs (0) and SCCs (1).

Four species of fish were captured in three macro- and meso-habitats in the bag seine (Table 70). Highest species richness (9) was found in ISB-BARS and lowest (1) in SCC-SHLW. The most commonly collected fish were fathead minnow (220) and white sucker (124). Most fathead minnows (189) were captured in SCN macrohabitat. Most white suckers were captured in SCC-SHLW (52) and SCN (47). Fathead minnow CPUE (fish/m^2) was highest in SCN (0.13) and ISB-BARS (0.03). Highest CPUE for white suckers was in SCC-SHLW (0.06) and ISB-BARS (0.02).

Three macro- and meso-habitats were sampled (CHXO, OSB, SCC-DEEP) with the benthic trawl. In 23 trawls, no fish were captured.

Four macro- and meso-habitats were sampled with trammel nets (Table 70). No fish were captured in CHXO, OSB, and SCC-DEEP and only walleye and channel catfish were captured in the WILD macrohabitat (i.e., Garrison Dam tailrace). Garrison Dam tailrace is the only macrohabitat where channel catfish were captured in segment **12**. In the tailrace, channel catfish and walleye CPUE (fish/100 m) was 0.7 and 0.4, respectively.

Table 69. Target species and numbers captured in Missouri River study segment **12** in 1996.

Species	CHXO	OSB	ISB	SCC	SCN	TRM	WILD	Total	% of Target
	Macrohabitats								
Fathead minnow			31		189	1		221	55
White sucker		5	25	52	47	5	3	137	34
River carpsucker		1			1	14		16	4
Walleye						15	1	16	4
Shorthead redhorse			1			4		5	1
Blue sucker						3		3	<1
Emerald shiner						2		2	<1
Channel catfish							2	2	<1
Bigmouth buffalo			1					1	<1
Sand shiner						1		1	<1
Total catch	0	6	58	52	237	45	6	**404**	
Species richness	0	2	4	1	3	8	3	**10**	
% of total target	0	1	14	13	59	11	1		

Table 70. Target taxa and numbers captured in Missouri River study segment **12** by gear and macro- and meso-habitat combination in 1996. A "-" means no fish were collected in that habitat. A blank space means the gear was not used in that habitat.

Taxa	CHXO	OSB	ISB-BARS	SCC-DEEP	SCC-SHLW	SCN	TRM	WILD	TOTAL
Bag Seine (23 hauls)									
Fathead minnow			31		-	189			220
White sucker			25		52	47			124
Bigmouth buffalo			1		-	-			1
Shorthead redhorse			1		-	-			1
									346
Benthic Trawl (23 tows)									
									0
Drifting Trammel Nets (24 drifts)									
Walleye	-			-				1	1
Channel catfish	-			-				2	2
									3
Boat Electrofishing (20 runs for a total time of 120 minutes)									
Fathead minnow		-					1		1
Emerald shiner		-					2		2
Sand shiner		-					1		1
White sucker		7					2		9
River carpsucker		2					13		15
Shorthead redhorse		-					2		2
Walleye		-					10		10
									40
Stationary Gill Net (6 sets for a total time of 18 hours)									
White sucker						-	1	3	4
River carpsucker						1	-	-	1
Shorthead redhorse						-	2	-	2
Blue sucker						-	3	-	3
Walleye						-	5	-	5
									15

Seven species of fish were captured in two macrohabitats by electrofishing (Table 70). Tributary mouth and OSB macrohabitats had species richness values of seven and two, respectively. The most commonly captured target fish were river carpsucker (15) and walleye (10). Most river carpsucker (13) and all walleye were captured in TRMs. Catch-per-unit-effort (fish/100 m) for both species was 0.3 in this macrohabitat.

Five species were captured in three macrohabitats in gill nets (Table 70). TRMs had highest species richness (4). The most commonly captured fish were walleye (5) with all individuals found in TRMs. Blue suckers (3) were captured only with gill nets in one TRM (i.e., Heart River). Highest CPUEs for walleye (0.4 fish/hour) and blue sucker (0.3 fish/hour) were in TRMs.

Six-hundred-twenty-eight non-target fish were captured (Table 71) in segment **12**, representing 17 species and 11 families (Catostomidae, Centrarchidae, Cyprinidae, Cyprinodontidae, Esocidae, Gasterosteidae, Ictaluridae, Osmeridae, Percidae, Percichthyidae, Salmonidae). Longnose sucker was the most commonly captured identifiable non-target species (74). Unidentified suckers were considered non-target species and constituted 43% of all fish captured (target + non-target). An attempt will be made to specifically identify these 1996 YOY suckers in the lab. Inside bend and SCN contained the most non-target fish, 318 and 230, respectively; whereas CHXO contained fewest (0).

The two Missouri River segments sampled in North Dakota were characterized by distinctly different fish communities. Most fish captured in segment **10** were members of the big-river faunal assemblage (flathead chub, sturgeon chub, sicklefin chub, blue sucker, shovelnose sturgeon, river carpsucker, smallmouth buffalo, bigmouth buffalo) (Pflieger 1975), and at least 17 of the 25 target benthic taxa are represented (members of the genus *Hybognathus* have yet to be identified to species). In contrast, samples from segment **12** yielded only 10 of 25 target taxa; fathead minnow and white sucker comprised 89% of target fish, even though they constituted <1% of fish in segment **10**. Few non-target fish sampled from segment **12** were members of the big-river faunal assemblage, and a majority are considered either small stream or introduced species.

Table 71. Non-target taxa and numbers captured in Missouri River study segment **12** in 1996.

	Macrohabitats								
Taxa	CHXO	OSB	ISB	SCC	SCN	TRM	WILD	Total	% of total
Unident. sucker			278		164			442	43
Longnose sucker		3	35	2	32	2		74	7
Unident. minnow				1	21			22	2
Common carp		4				17		21	2
Smallmouth bass		1				18		19	2
Yellow perch					6	7		13	1
Johnny darter		1		1		5		7	<1
Northern pike				1	1	4		6	<1
Rainbow smelt			5					5	<1
Banded killifish					4			4	<1
Bluegill						3		3	<1
Unident. *Lepomis*						3		3	<1
Ciscoe							2	2	<1
Black crappie						1		1	<1
Brook stickleback					1			1	<1
Black bullhead						1		1	<1
Golden shiner						1		1	<1
Goldeye						1		1	<1
Spottail shiner					1			1	<1
White bass						1		1	<1
Total catch	0	9	318	5	230	64	2	**628**	
Species richness	0	4	3	4	8	13	1	**17**	

The large number of native, big river species still found in segment **10** may be attributable to the retention of river conditions similar to those of pre-impoundment, such as a March and June rise, high sediment load, and river-floodplain interaction (Hesse et al. 1989). Conversely, an absence or reduction of these conditions explains the absence of many native species and occurrence of many introduced species in segment **12**.

Difference in species composition and macrohabitat use between segments **10** and **12** can be attributed to river morphological and hydrological differences. Changes in the hydrologic cycle and channel morphology in several impounded stretches of the Missouri River have led to reductions in important fish habitat and the demise of many native fish species (Hesse et al. 1989). This seems to be the case in segment **12** as well.

Meetings/presentations. - In late July, we met with Greg Power (Central District Fisheries Supervisor), Fred Ryckman (District Fisheries Biologist), Jeff Hendrickson (Fisheries Biologist), and Jason Lee (Assistant Fisheries Biologist) of the North Dakota Game and Fish Department (NDGF). The impetus of the meeting was to brief NDGF on scope and intent of this project, as well as sampling design and to answer any questions. Dissertation research was also discussed. Standard operating procedures developed for this project were examined and discussed in detail to provide NDGF a better understanding of the data collection process. NDGF were also shown quick reference guides we had developed for our field crew outlining gear and methods for fish and habitat data collection in each macro- and meso-habitat.

The MRBFC held two workshops in 1996, one in June and one in November. During the June workshop, we presented current progress information and an abridged dissertation proposal. This proposal acknowledges that many Missouri River fish species interact ecologically, and that these interactions can differ among river segments. The Missouri River Benthic Fish Study was designed to describe habitat use and community structure of target benthic fish among and between sections and segments of the Missouri River. Additionally, ecological interactions present another excellent opportunity to compare fish communities among and between sections and segments.

Members of the family Catostomidae have diverged recently from a common ancestor and evolved together in the Missouri River system, competing for food and space and continually defining and redefining their positions in relation to each other. In segments which more closely resemble the "natural" Missouri River, these fish may have less niche overlap or greater niche distinctiveness than in segments that have been adversely affected by dams or other man-made alterations.

Niche relations among suckers will be determined by examining the pattern of microhabitat and food resource use and partitioning by members of this group of fishes. The pattern of microhabitat use for suckers will be examined in each segment of the Missouri River, while food resource use will be examined only in the two North Dakota segments (segments **10** and **12**).

At the November workshop, a synopsis of 1996 fish and habitat data was presented.

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Section 6 : Upper Inter-Reservoir III and Unchannelized Area, South Dakota
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Study area. - The South Dakota Coop Unit is responsible for section **6** which includes segments **14, 15** and **16**. Segments **14** and **15** were chosen for study in 1996 and are transition areas for the river between upper, more natural segments, and lower channelized segments. Segments **14** and **15** are quite different from each other and will be described separately. Segment **16** is not discussed because it was not sampled in 1996.

Segment **14** extends from Fort Randall Dam at Pickstown, SD to the Niobrara River mouth in NE. The valley in this segment is fairly confined with bluffs immediately bordering both shorelines for much of the length resulting in low channel sinuosity. The exception to this is the last five miles upstream from the Niobrara River where the Missouri River begins to widen, creating many backwater areas. The few bends in segment **14** are gradual and make defining beginning and endpoints difficult. Flow in this segment is primarily regulated by Fort Randall Dam since there are no significant tributaries. Power peaking operations from this dam often cause erratic flow fluctuations that can change available habitats within hours. The dam tailrace area is heavily fished and used for recreation, but the rest of the segment receives relatively little fishing or recreational use except on holidays. Although this section does not have any cities along the banks, the Nebraska side has several cottages along its shoreline and a small development near Niobrara. The South Dakota side has a couple homes near the river at Greenwood. Agriculture in this area is forced back from the river by steep bluffs.

Segment **15** extends from Gavins Point Dam, slightly west of Yankton, SD, to Ponca St. Park near Ponca, NE. This section has a large floodplain with northern bluffs being nearly absent due to the James and Vermillion River Valleys. The river in this segment is as much as a half mile wide in some areas. Numerous islands, sand bars, side channels, and flooded vegetation are common. Sinuosity is much greater in this segment as it meanders and braids through the wide floodplain. Despite the great width of the river bed in this segment, the main channel, or thalweg, is perhaps the smallest and least defined here. The river bed is often characterized by multiple thalwegs carrying equal amounts of water, separated by elevated, yet submerged sandbars. Because of the wide channel, meanders, and braids, current velocity here is generally lower than segments above and below it. Segment 15 flows are primarily controlled by Gavins Point Dam, but are also influenced by several small tributaries. This segment receives heavy recreational use during summer months from area residents, especially from Yankton, SD and from visitors to the Corps of Engineers park and campgrounds at the base of the dam. The remainder of the river is continuously, but not heavily populated. Two parks: Clay County, SD and Ponca State Park, NE also contribute recreational use during the summer, but to a lesser degree than Yankton. River shorelines are fertile and flat and are subsequently farmed to the bank edges.

Standard operating procedures. - South Dakota is responsible for stationary gill net, substrate, geographic positioning system, and fish treatment SOPs. Changes which were discussed at the November meeting in Omaha only affect the first two.

In the stationary gill net SOP, duration and time of deployment was changed from a 3 hour morning set to an overnight 12-18 hour set. Net sets in small tributaries were reoriented to be perpendicular rather than parallel to shore. In ISB-POOL, 2 nets (one in each of two separate pools within a macrohabitat) will now be set.

In the substrate SOP, equipment and methods have been modified. The sampler will now use a chain yoke to help dredging problems which arose because of a former single attachment point. Criteria for a full pull has been changed to a half full dredge or the distance from the midpoint of the sub-sample to the end of the sub-sample. Changes to both SOPs are being submitted to all MRBFC members for approval.

Field sampling. - Field sampling went well this year with respect to methods and operation. Seemingly low catch rates were our only concern. Trammel nets and especially benthic trawls provided little in terms of catch-per-unit-effort this season, however they were the only two gears in which certain target species were collected. Bag seines and electrofishing were our two most productive gears. This is not surprising when considering the habitat types where these gears were deployed (banks, sandbars, and vegetation). Gill nets caught fish, but seemed to fall short of their potential as a gear. Small mesh panels rarely caught fish. Overnight sets in 1997 may change this dramatically.

Macrohabitat definitions presented some confusion this year because of our unique segments. Many habitats loosely matched criteria suggested as guidelines for habitat identification. We provided detailed comments on our data sheets when questionable methods were used or decisions made. Discussions at the November Meeting and amended habitat classifications should eliminate confusion in 1997.

Thirteen families (6 target) were collected in 1996 (Table 72). Cyprinidae was the most abundant family, represented by 14 species (7 target) and 2,845 individuals (2,586 target). Centrarchidae was the next most abundant family, represented by 10 species (0 target) and 1,098 individuals (0 target). Catostomidae was the third most abundant family, represented by 7 species (5 target) and 608 individuals (304 target). Percidae was the fourth most abundant family, represented by 5 species (2 target) and 141 individuals (38 target). Ictaluridae was the fifth most abundant family, represented by 4 species (3 target) and 82 individuals (80 target).

Boats are receiving additional servicing and parts this spring, which should extend their life this season. Eighteen rather than 12 trammel nets will be ordered this year due to the large numbers of snags we experienced in 1996. Also, we may purchase a new YSI conductivity and temperature meter this year to replace the analog one we have been using. We foresee no problems with the 1997 field season and expect to accomplish even more this year than last.

Meetings/presentations. - Results from preliminary sampling and the first field season were reported at the MRBFC June and November workshops, respectively.

Table 72. Total numbers and percent of total catch of all fish taxa collected from Missouri River study section **6** (segments **14** and **15**; South Dakota) in 1996.

Fish taxa	Family	Total catch	% of total catch
Target Benthic Fish			
bigmouth buffalo	Catostomidae	4	<1
blue sucker	Catostomidae	3	<1
brassy minnow	Cyprinidae	70	1
channel catfish	Ictaluridae	48	1
common carp	Cyprinidae	147	2
emerald shiner	Cyprinidae	2241	37
flathead catfish	Ictaluridae	30	<1
flathead chub	Cyprinidae	6	<1
freshwater drum	Sciaenidae	32	1
river carpsucker	Catostomidae	229	4
sand shiner	Cyprinidae	120	2
sauger	Percidae	17	<1
shorthead redhorse	Catostomidae	60	1
shovelnose sturgeon	Acipenseridae	13	<1
sicklefin chub	Cyprinidae	1	<1
smallmouth buffalo	Catostomidae	8	<1
stonecat	Ictaluridae	2	<1
w. silvery minnow	Cyprinidae	1	<1
walleye	Percidae	21	<1
Non-Target Fish			
bigmouth shiner	Cyprinidae	4	<1
black bullhead	Ictaluridae	2	<1
black crappie	Centrarchidae	12	<1
bluegill	Centrarchidae	70	1
gizzard shad	Clupeidae	827	14
goldeye	Hiodontidae	23	<1
grass carp	Cyprinidae	1	<1
green sunfish	Centrarchidae	10	<1
green sunfish x orange-spotted sunfish	Centrarchidae	1	<1
johnny darter	Percidae	22	<1
largemouth bass	Centrarchidae	122	2
longnose gar	Lepisosteidae	3	<1
northern pike	Esocidae	4	<1
paddlefish	Polyodontidae	2	<1

Table 72. Continued.

Fish taxa	Family	Total catch	% of total catch
Non-Target Fish			
quillback	Catostomidae	32	1
red shiner	Cyprinidae	51	1
river shiner	Cyprinidae	22	<1
rock bass	Centrarchidae	2	<1
sauger x walleye	Percidae	1	<1
shortnose gar	Lepisosteidae	12	<1
smallmouth bass	Centrarchidae	88	1
spotfin shiner	Cyprinidae	92	2
spottail shiner	Cyprinidae	6	<1
unidentified centrarchid	Centrarchidae	14	<1
white bass	Percichthyidae	83	1
white crappie	Centrarchidae	776	13
yellow perch	Percidae	80	1
Age-0 fish		233	4
unidentified lepomis	Centrarchidae	3	<1
unidentified shiner	Cyprinidae	83	1
unidentified sucker	Catostomidae	272	5

Section 7 : Channelized I, Iowa
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Study area. - The Iowa section (section *7*) begins below the Big Sioux River confluence at rkm 1192/rmi 740.0 and ends at Rulo, Nebraska (rkm 802/rmi 498.0). Section *7* was divided into four segments based primarily on tributary inputs to the Missouri River. Those segments are (as numbered by their longitudinal succession in the overall project): *17*)Big Sioux River to Little Sioux River (rkm 1192-1078/rmi 740.0 - 669.2), *18*) Little Sioux River to Platte River (rkm 1078-959/rmi 669.2 - 595.5), *19*) Platte River to Nishnabotna River (rkm 959-873/rmi 595.5 - 542.0), and *20*) Nishnabotna River to Rulo, Nebraska (rkm 873-802/rmi 542.0 - 498.0). Segments *17, 18*, and *19* were sampled during the 1996 field season. Within these segments, several TRM, CHXO, ISB, and OSB macrohabitats were available to allow for a random sample of five of each. However, SCC macrohabitats were limited and no SCN macrohabitats were available during sampling.

Standard operating procedures. - In late winter 1996, SOPs were written and sent for review among Consortium members for beach seine sampling and for collection of age and growth data. Both SOPs followed procedures agreed upon during the November 1995 workshop. Revisions were made to SOPs, at the June 1996 workshop, after preliminary field testing in May and June. Upon completion of the field season, further improvements have been incorporated.

Preliminary/additional sampling. - Between May and June, we tested SOPs by sampling three replicates of the macrohabitats available in segment *17* (Channel Crossover - CHXO, Outside Bend - OSB, Inside Bend - ISB, and Tributary Mouth - TRM). Generally, catch rates were fairly low (Table 73) with electrofishing catching the most fish. Non-baited hoopnets (375-mm bar mesh) were also tested as a possible addition to SOPs in our spring sampling. In 24 net sets, four fish were caught yielding an effort of 0.2 fish/net set.

Table 73. Catch-per-unit-effort for each gear used during preliminary 1996 sampling in Missouri River study section 7 macrohabitats (CHXO - Channel Crossover; ISB - Inside Bend; OSB - Outside Bend; TRM - Tributary Mouth). A "-" indicates the gear was not used in that macrohabitat.

	CHXO	ISB	OSB	TRM
Beach Seine (#/Haul)	-	25.3	-	-
Drift Net (#/Drift)	1.3	0.0	0.2	0.0
Benthic Trawl (#/Drift)	0.0	0.0	0.2	0.0
Gill Net (#/hr)	-	1.9	-	0.6
Electrofishing (#/Min)	-	1.0	0.3	0.8

When time allowed, several non-SOP gears or methods were tested during summer/fall field work for possible future use (Table 74). Catch rates continued to be low for hoopnets. However, drifting trammel nets over sandbars were effective for shovelnose sturgeons and blue suckers. From this non-SOP sampling some modifications to the SOP sampling were suggested at the November workshop.

Field sampling. - Field work using finalized SOPs began on 22 July and was completed on 6 September. A total of 47 species representing 14 families were collected from section 7 in 1996. Emerald shiner, gizzard shad, flathead catfish, goldeye, river shiner, and channel catfish were most abundant (Table 75).

Meetings/presentations. - Two oral presentations were given in 1996. The first presentation was given at the joint Iowa and Nebraska Chapters of the American Fisheries Society (AFS) annual meeting (January 1996); whereas the second was given at the North Central Division AFS - Rivers and Streams Mid-Year Technical Meeting (April 1996). Both presentations were overview in nature, discussing the general basis for the project and methodology used to collect fish and physicochemical data. The Consortium also presented a poster at the 58th Midwest Fish and Wildlife Conference in December 1996. We also attended three (April, June and November) benthic fish workshops in 1996.

Miscellaneous activities. - Throughout the year, a large amount of time was devoted to preparing and ordering equipment for field work, hiring personnel, preparing for workshops, and writing and reviewing documents. The Iowa and Nebraska representatives from the Missouri River Natural Resources Committee (MRNRC) were also periodically updated on field work and general progress of the project. These representatives and fisheries biologists from the Missouri Department of Conservation were also invited to observe field work.

Table 74. Catch-per-unit-effort (CPUE) for non-SOP (i.e., additional) sampling in Missouri River study section 7 in 1996.

Method	CPUE
Trammel Seine in Wing Dam Pool	3.0/net
Benthic Trawl in Wing Dam Pool	2.0/haul
Set Trammel Net Across Mouth of Tributary	8.5/hr
Set Trammel Net in Wing Dam Pool (Overnight)	0.4/hr
Drifting Trammel Net Over Inundated Sand Bars	2.8/net
Electrofishing (60 Hz - Outside Bends)	0.5/min
Electrofishing (40 Hz - Outside Bends)	0.1/min
Fyke Nets	2.0/net
Hoopnets (Non-Baited and Baited w/ cheese or cotton seed cakes)	0.9/net

Table 75. Total catch in Missouri River study section 7 (Iowa/Nebraska) in 1996 ("*" indicates a targeted benthic species).

Species	Total Catch	% Total Catch	% Benthic Fish Catch
Emerald shiner*	1693	47	73
Gizzard shad	895	25	
Flathead catfish*	227	6	10
Goldeye	179	5	
River shiner	108	3	
Channel catfish*	106	3	5
Spotfin shiner	86	2	
Brassy minnow*	58	2	2
Common carp*	47	1	1
River carpsucker*	31	1	1
Speckled chub	25	1	
Shovelnose sturgeon*	17	<1	1
Shortnose gar	10	<1	
Freshwater drum*	9	<1	<1
Sturgeon chub*	9	<1	<1
White crappie	9	<1	
Sauger*	8	<1	<1
Red shiner	7	<1	
Silver chub	7	<1	
White bass	7	<1	
Bluegill	4	<1	
Blue sucker*	4	<1	<1
Quillback	4	<1	
Walleye	4	<1	<1
Black bullhead	2	<1	

Table 75. Continued.

Species	Total Catch	% Total Catch	% Benthic Fish Catch
Black crappie	2	<1	
Bigmouth buffalo	2	<1	<1
Largemouth bass	2	<1	
River redhorse	2	<1	
Spottail shiner	2	<1	
W. Silvery minnow*	2	<1	<1
White perch	2	<1	
Bighead carp	1	<1	
Brook silverside	1	<1	
Bigmouth shiner	1	<1	
Fathead minnow*	1	<1	<1
Green sunfish	1	<1	
Grass carp	1	<1	
Northern hogsucker	1	<1	
Northern pike	1	<1	
Paddlefish	1	<1	
Sicklefin chub	1	<1	<1
Shorthead redhorse	1	<1	<1
Smallmouth bass	1	<1	
Sand shiner*	1	<1	<1
Stonecat*	1	<1	<1
Threadfin shad	1	<1	

Section 8 : Channelized II, Kansas

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Study area. - The Kansas Coop Unit is responsible for section *8*, which encompasses segments *21, 22, 23*, and *24*. Segments *21, 22*, and *23* were sampled in 1996. Segment *21* extends from Rulo, NE (rkm 802/rmi 498.0) to St Joseph, MO. At St. Joseph, navigation channel velocities decrease (Slizeski et al. 1982). Segment *22* extends from St. Joseph, MO to the Kansas River mouth (rkm 592/rmi 367.5). Segment *23* extends from the Kansas River mouth to the Grand River mouth at rkm 403/rmi 250.0. Segment *24* (and section *8*) ends at Glasgow, MO where average floodplain width decreases from 8 to 3 km as the river enters the Ozark border.

Standard operating procedures. - The Kansas Unit is responsible for electrofishing, turbidity, and water temperature and conductivity SOPs. Initial drafts were developed in late winter-early spring and circulated to MRBFC members. Some modifications have since been proposed and incorporated into 1997 drafts. Modifications include electrofishing the following additional macro- and meso-habitats; SCC-DEEP, SCN, and TRM-LRGE.

Preliminary/additional sampling. - Spatial and temporal use of tributary confluences by fishes in the Lower Missouri River is being investigated. Eight small tributaries (equivalent to TRM-SMLL in the MRBFC) between Rulo, NE and Waverly, MO were selected as study sites. Sampling was conducted in June, October, and December 1996, and will continue through December 1997. Sampling protocol consists of blocking off short (20-40 m) sections of each tributary confluence with trammel nets, then "trammel-net seining" within the blocked off section to collect fishes. Fishes collected in three passes with the trammel seine and those caught in the block trammel nets (originating from within the blocked-off section as determined when block trammel nets are pulled) compose the catch. In addition, several physicochemical variables are measured.

Twenty-two species and over 500 individuals have been collected to date. Preliminary results indicate ten species (bighead carp, common carp, channel catfish, freshwater drum, goldeye, river carpsucker, sauger, smallmouth buffalo, shortnose gar, and gizzard shad) compose greater than 85% of the species collected, and are always present in tributary confluences. Other species (e.g., white crappie, bigmouth buffalo) frequent these areas only during specific times of the year. For some age and growth species, more individuals were collected from tributary confluences in this study than were collected during the entire benthic fish study sampling period.

Field sampling. - Sampling for the benthic fish study was initiated on 29 July and concluded on 27 September, 1996. River discharge in the Kansas section of the Missouri River was high throughout most of the late summer and early fall. Although sampling was not hindered by high discharge, gear effeciency was probably diminished. Five randomly-selected replicates of each of the continuous macrohabitats (OSB, ISB, MNC) were completed in three study segments. The full compliment of five replicates of discrete macro- and meso-habitats did not exist in all segments; however, five replicates were obtained for the macro- and meso-habitats that were present (Table 8).

Forty-four species and greater than 4,500 individuals were collected during the 1996 sampling period. Four species (gizzard shad, emerald shiner, brassy minnow, and channel catfish) composed about 74% of the total number of fishes collected (Table 76). Seven benthic species (emerald shiner, brassy minnow, flathead catfish, channel catfish, river carpsucker, shovelnose sturgeon, freshwater drum) composed ≥ 2.0% of fishes collected in most segments, while other benthic species were relatively rare (< 2.0%).

In section *8*, the numbers of target age and growth species collected varied among sampling gears used. Electrofishing collected the greatest number of species (11), and accounted for about 53% of the total catch of target age and growth species (Table 77). Greater than 50% of the total catch of emerald shiners, flathead catfish, freshwater drum, river carpsucker, sauger, and smallmouth buffalo were collected using electrofishing. The benthic trawl collected nine species, and 8% of the total catch of age and growth species. The benthic trawl was the only gear that collected sicklefin chubs. Although high water during the 1996 sampling period limited bag seine use, eight species and about 32% of the total catch of age and growth species were collected with this gear. Bag seine catch was

Table 76. Number and percentages of fishes collected in the Kansas portion of the Missouri River, Section *8*, Segments *21, 22, 23* in 1996. An * designates target benthic species.

Species	Segment *21*		Segment *22*		Segment *23*	
	number	(%)	number	(%)	number	(%)
Gizzard shad	258	22.4	612	37.1	825	48.2
Emerald shiner*	203	17.7	241	14.6	162	9.5
Brassy minnow*	182	15.8	291	17.6	153	8.9
Flathead catfish*	94	8.2	40	2.4	34	2.0
Channel catfish*	79	6.9	131	7.9	193	11.3
Common carp*	49	4.3	23	1.4	31	1.8
River carpsucker*	43	3.7	34	2.1	22	1.3
Silver chub	36	3.1	61	3.7	16	0.9
Shovelnose sturgeon*	30	2.6	48	2.9	40	2.3
Goldeye	29	2.5	13	0.8	8	0.5
Freshwater drum*	26	2.3	36	2.2	41	2.4
Red shiner	20	1.7	21	1.3	29	1.7
White bass	18	1.6	10	0.6	16	0.9
River shiner	17	1.5	4	0.2	29	1.7
Sauger*	10	0.9	16	1.0	8	0.5
Shortnose gar	9	0.8	16	1.0	32	1.9
Orangespotted sunfish	7	0.6	9	0.5	4	0.2
Longnose gar	5	0.4	5	0.3	1	0.1
Green sunfish	5	0.4	4	0.2	1	0.1
Sicklefin chub*	5	0.4	4	0.2	2	0.1
Sand shiner*	3	0.3	1	0.1	4	0.2
Sturgeon chub*	3	0.3	1	0.1	3	0.2
Blue sucker*	3	0.3	3	0.2	7	0.4
Speckled chub	2	0.2	0	0.0	5	0.3
White crappie	2	0.2	2	0.1	0	0.0
Flathead chub*	2	0.2	0	0.0	3	0.2
Bigmouth shiner	1	0.1	0	0.0	0	0.0
Spotfin shiner	1	0.1	1	0.1	0	0.0
Bluegill	1	0.1	3	0.2	15	0.9
Shorthead redhorse*	1	0.1	0	0.0	0	0.0
Black bullhead	1	0.1	0	0.0	0	0.0
Walleye*	1	0.1	0	0.0	1	0.1
Smallmouth buffalo*	1	0.1	3	0.2	5	0.3
Northern pike	1	0.1	0	0.0	0	0.0
Spotted gar	1	0.1	0	0.0	0	0.0
Highfin carpsucker	1	0.1	0	0.0	0	0.0
Grass carp	0	0.0	0	0.0	1	0.1
Golden shiner	0	0.0	0	0.0	3	0.2
Largemouth bass	0	0.0	0	0.0	6	0.4
Mosquitofish	0	0.0	0	0.0	2	0.1
Bullhead minnow	0	0.0	0	0.0	1	0.1

Table 76. Continued.

Species	Segment *21*		Segment *22*		Segment *23*	
	number	(%)	number	(%)	number	(%)
Quillback	0	0.0	1	0.1	0	0.0
Blue catfish*	0	0.0	15	0.9	8	0.5
Spotted bass	0	0.0	0	0.0	2	0.1
Total	1150		1649		1712	

Table 77. Percent of age and growth species collected with five gear types in the Kansas section (*8*) of the Missouri River in 1996. EF = boat electrofishing, BT = benthic trawl, BS = bag seine, DTN = drifting trammel net, SGN = stationary gill net.

Species	EF	BT	BS	DTN	SGN
Emerald shiner	92.7	0.5	6.8		
Brassy minnow	21.5	0.3	78.2		
Channel catfish	26.6	35.2	35.5	1.0	1.7
Flathead catfish	98.2	0.6		0.6	0.6
Shovelnose sturgeon		12.3		58.8	28.9
Freshwater drum	70.2	11.5	15.4		2.9
River carpsucker	52.7	2.2	31.9	2.2	11.0
Sauger	70.6		8.8	2.9	17.6
Blue sucker	46.2	7.6		46.2	
Sicklefin chub		100.0			
Smallmouth buffalo	66.7			11.1	22.2
Sand shiner	14.3		85.7		
Flathead chub	40.0		60.0		
% of total	53.0	8.0	32.0	4.0	3.0

dominated by *Hybognathus* spp. The drifting trammel net was very effective at collecting shovelnose sturgeon on ISBs, but only accounted for about 4% of the total catch of age and growth species. Similarly, stationary gill nets in ISB-POOLs were effective for shovelnose sturgeon, but this gear collected only 3% of the total age and growth species.

Meetings/presentations. - The Kansas Cooperative Fish and Wildlife Research Unit (KSCRU) attended all three MRBFC workshops in 1996. In addition, the KSCRU presented a poster titled, "Stranding of *Pentagenia vittigera* following flow reductions in the lower Missouri River" at the 58th Midwest Fish and Wildlife Conference. The Unit has also submitted a manuscript, "Stranding of *Pentagenia vittigera* following flow reductions in the lower Missouri River" to the Journal of Freshwater Ecology. This manuscript is now in press.

Section 9 : Channelized III, Missouri

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Study area. - The Missouri Coop Unit is responsible for section *9*, which encompasses segments *25, 26*, and *27*. Segment *25* extends from Glasgow, MO, where average floodplain width decreases from 8 to 3 km, to the Osage River mouth. The Osage River contributes a substantial amount of clearer water to the Missouri River because the drainage basin flows from the Ozark Uplands and has two large mainstem reservoirs. Segment *26*, which was not sampled in 1996, extends from the Osage River to a point where the Missouri River enters the Mississippi Alluvial Valley (about rkm 80/rmi 50). Segment *27* then flows from this point to the confluence with the Mississippi. Segment *27* is unique, in that it has more secondary channels than other channelized segments and includes the Mississippi/Missouri River confluence area.

Standard operating procedures. - The Missouri Unit was responsible for developing SOPs for aquatic macrohabitat classifications, depth and velocity measurements, quantification of bed contours, and fish codes for all fish species that might be encountered in the Missouri River. Aquatic habitat descriptions, four letter fish codes, and methods to measure depth, velocity, and bed form can be found in Sappington et al (1996).

Preliminary/additional sampling. - Preliminary field sampling and gear testing began in late March, continued through July and was resumed in late October-early November. MRBFC standardized gears were used to collect fishes during preliminary sampling; drifting trammel nets, stationary gill nets, boat electrofishing, a benthic trawl, and a bag seine. Hoop nets, a non-standard gear were evaluated as an alternative gear in Spring and Fall. Hoop nets were run unbaited over night. Five hoop nets were run for four nights (i.e., 20 net nights) in late April-early May. These hoop nets were about 3.66 m long, with six hoops (0.61 m, diameter of first hoop), and 2.54 cm mesh. Six hoop nets were run for five days (30 net nights) in late October-early November. These nets were all 4.58 m long, with seven hoops (1.07 m diameter of first hoop), and had throats placed on the second and fourth hoop. Three different mesh sizes (i.e., 2 hoop nets of each) were used; 2.54, 5.08, and 7.62 cm. We attempted to fish these gears in each macrohabitat following SOPs to evaluate our techniques and to familiarize ourselves with their operation.

Two-thousand-eighty-five individuals representing 28 fish species were collected during preliminary sampling and gear testing in 1996 (Table 78). Gizzard shad were the most abundant species collected (91% of the total) followed by river carpsucker (1%), channel catfish (1%), and shortnose gar (1%). Uncommon species were paddlefish, northern pike, silver chub, bluegill, sicklefin chub, green sunfish, and sauger. Boat electrofishing collected the greatest number of individuals, mostly gizzard shad, followed by gill nets, seines, and hoop nets. These four gears also collected the most benthic species. Drifting trammel nets and the benthic trawl collected few individuals and few species. Based on preliminary data, seining, electrofishing, gill netting, and hoop netting appeared to be the best gears. These trends were similar to those reported in 1995 (Galat and Dieterman 1995).

The Missouri River inundated its floodplain following heavy rainfall in Iowa and northern Missouri in June, 1996 (Figure 1). We had just finished setting up our electrofishing boat at this time and needed to evaluate its electric field. For three days we electrofished the floodplain to test our new boat and to describe the fish community present. We conducted eight, 10 minute electrofishing runs on the floodplain of two tributaries; Perche Creek (a TRM-SMLL at rmi 171), and the Lamine River (a TRM-LRGE at rmi 202.5). These floodplains provide areas of reduced water velocity due to natural and man-made levees. We collected 11 species on the floodplain (Table 79). Five of these species were in the benthic fish guild. The most abundant were common carp, freshwater drum, gizzard shad, and river carpsucker. The least abundant were northern pike, channel catfish, shortnose gar, and striped bass.

Field sampling. - The field season began July 28 and continued to September 18. Sampling was delayed briefly in early September due to a broken boat motor and depth sounding reel.

Physicochemical variables at fish collection locations varied between segments and among macro- and meso-habitats (Tables 80). Average depths ranged from 0.25-13.7 m in segment *25* and 0.15-7.9 m in segment *27*. In segment *25*, average column velocities ranged

Table 78. Total numbers of fish species and percent of total collected in six gears (sample size) during preliminary sampling and gear testing in Missouri River study section *9*. Sampling was conducted from late March through July and again in late October/early November 1996.

Taxa	Bag seine (11 hauls)	Boat electrofish (10 runs)	Benthic trawl (8 tows)	Gill net (10 sets)	Trammel net (4 drifts)	Hoop net (50 nights)	Total	% of Total
Gizzard shad	9	1883		10			1902	91%
*River carpsucker	1	6		8		12	27	1%
*Channel catfish	1		4	2		16	23	1%
Shortnose gar	6	7		7			20	1%
Goldeye		5		10		3	18	1%
*Common carp		11		3		1	15	1%
*Emerald shiner	15						15	1%
Longnose gar				8			8	T
**Hybognathus* spp.	7						7	T
*Flathead catfish		2				4	6	T
Striped bass		5		1			6	T
*Smallmouth buffalo		1	1	1		2	5	T
*Bigmouth buffalo	1	1		1		2	5	T
*Blue catfish		2		1		1	4	T
*Shovelnose sturgeon						3	3	T
*Freshwater drum		1		1		1	3	T
Red shiner	3						3	T
*Walleye	1					1	2	T
Largemouth bass	1	1					2	T
Rainbow smelt	2						2	T

* denotes species in the benthic fish guild, T= less than 1%

Table 78. Continued.

Taxa	Bag seine (11 hauls)	Boat electrofish (10 runs)	Benthic trawl (8 tows)	Gill net (10 sets)	Trammel net (4 drifts)	Hoop net (50 nights)	Total	% of Total
Speckled chub	2						2	T
Paddlefish				1			1	T
Northern pike				1			1	T
Silver chub		1					1	T
Bluegill		1					1	T
*Sicklefin chub	1						1	T
Green sunfish	1						1	T
*Sauger	1						1	T
Total numbers	52	1,927	5	55	0	46	2,085	
richness (all spp.)	15	14	2	14	0	11	28	
richness (benthic)	8	7	2	7	0	10	14	

*denotes species in the benthic fish guild, T=less than 1%

Table 79. Species composition, total number and relative abundance, expressed as average catch per minute (CPUE) of fishes collected from the Missouri River floodplain between rkms 269 and 325 (rmi167-202), by boat electrofishing in June 1996. An * indicates the species is a target benthic fish.

Species	Total number collected	CPUE (± SD)
*Common carp	40	0.51 (0.49)
*Freshwater drum	16	0.20 (0.23)
Gizzard shad	12	0.15(0.17)
*River carpsucker	12	0.16(0.15)
*Smallmouth buffalo	7	0.10(0.12)
Grass carp	3	0.04(0.07)
Bluegill	2	0.03(0.05)
Northern pike	1	0.01(0.04)
*Channel catfish	1	0.01(0.04)
Shortnose gar	1	0.01(0.04)
Striped bass	1	0.03(0.07)

Table 80. Physicochemical variable means (± 1 SD) measured at benthic fish collection sites in macro- and meso-habitats in segments *25* (rmi 220-130, rkm 354-209) and *27* (rmi 50-0, rkm 80-0) during July to September, 1996. Macro- and meso-habitat acronyms are from Sappington et al. (1996). Cobble substrates are qualitatively assessed as 0=not present, 1=incidental, 2=dominant, and 3=ubiquitous.

Macro- and meso-habitat	depth (m)	velocity (m/s)	conductivity (uS/cm)	turbidity (NTUs)	water temperature (^oC)	cobble	Substrate gravel (%)	Substrate sand (%)	Substrate silt (%)
				Segment *25*					
CHXO	6.25	1.68	646	660	26.0	0	2.75	97.20	0
	(0.66)	(0.39)	(80)	(489)	(0.29)		(4.36)	(4.38)	
OSB	4.38	1.13	638	527	25.8	1.20	3.94	53.34	3.57
	(0.41)	(0.18)	(67)	(384)	(0.19)	(0.19)	(2.90)	(2.71)	(5.89)
ISB-BARS	0.72	0.22	629	396	25.8	0	0	63.00	37.00
	(0.03)	(0.07)	(49)	(233)	(0.47)			(30.33)	(30.33)
ISB-CHNB	4.77	1.14	634	625	25.9	0	1.40	95.60	3.00
	(0.93)	(0.40)	(76)	(508)	(0.21)		(2.19)	(6.27)	(6.71)
ISB-STPS	2.31	0.33	624	402	26.0	0.34	0	49.20	37.20
	(0.47)	(0.06)	(51)	(207)	(0.25)	(0.48)		(46.08)	(42.83)
ISB-POOL	5.86	0.35	619	410	25.7	0	0.40	58.60	41.00
	(4.98)	(0.24)	(49)	(219)	(0.43)		(0.89)	(42.60)	(43.07)
SCN*	2.08	0.00	706	13	23.5	0	0	10.00	90.00
SCC-SHLW	0.39	0.09	625	633	24.1	0	0	98.75	1.25
	(0.19)	(0.01)	(91)	(809)	(3.25)			(1.77)	(1.77)
SCC-DEEP	3.47	0.78	659	427	24.7	0	0.33	65.00	34.67
	(0.79)	(0.39)	(51)	(503)	(2.55)		(0.58)	(30.41)	(30.09)
TRM-SMLL	1.42	0.004	489	61	24	0	0	0	100.00
	(0.32)	(0.009)	(249)	(33)	(2.28)				(0.00)
TRM-LRGE*	4.80	0.08	235	82	24.9	0	1.25	3.75	95.00
				Segment *27*					
CHXO	5.89	1.72	735	128	27.2	0	1.63	85.88	12.50
	(0.60)	(0.19)	(24)	(20)	(0.77)		(2.29)	(24.35)	(25.00)
OSB	4.78	0.94	709	193	26.9	1.50	27.03	42.68	2.86
	(0.45)	(0.52)	(46)	(105)	(0.47)	(0.39)	(41.59)	(37.00)	(6.39)
ISB-BARS	0.60	0.15	668	278	27.3	0.10	10.00	29.80	60.20
	(0.14)	(0.11)	(80)	(224)	(0.45)	(0.22)	(18.46)	(27.24)	(41.35)
ISB-CHNB	4.24	1.41	735	131	27.1	0.20	20.40	79.60	0
	(0.95)	(0.58)	(23)	(21)	(0.61)	(0.45)	(44.50)	(44.50)	
ISB-STPS	2.37	0.23	679	279	27.0	1.00	0	19.47	47.20
	(0.51)	(0.11)	(89)	(224)	(0.25)	0		(17.98)	(17.99)
ISB-POOL	7.00	0.22	673	257	27.0	0	6.00	75.00	19.00
	(1.31)	(0.10)	(86)	(241)	(0.40)		(13.42)	(34.28)	(28.81)
SCN	0.81	0.07	635	93	27.7	0.06	7.00	37.00	56.00
	(0.69)	(0.11)	(157)	(49)	(1.17)	(0.13)	(15.65)	(44.10)	(51.77)
SCC-SHLW	0.26	0.21	NA	119	NA	0	0	96.00	4.00
	(0.16)	(0.06)		(1)				(5.66)	(5.66)
SCC-DEEP	2.13	0.62	756**	69	28.2**	0	17.67	57.33	25.00
	(0.65)	(0.51)		(39)			(12.70)	(50.86)	(43.30)

Table 80. Continued.

Macro- and meso-habitat	depth (m)	velocity (m/s)	conductivity (uS/cm)	turbidity (NTUs)	water temperature (°C)	Substrate cobble	gravel (%)	sand (%)	silt (%)
TRM-SMLL	1.01 (0.39)	0.01 (0.02)	678 (39)	95 (41)	26.3 (0.35)	0	0	0.57 (0.98)	99.43 (0.98)
TRM-LRGE*									

*only one replicate in segment *25* and no replicates in segment *27*
NA-equipment problems-no measurements taken
**equipment problems-one measurement taken

from 0.00 m/s in TRM-SMLL to 1.98 m/s in CHXOs. In segment *27*, average column velocities ranged from 0.00 m/s in ISB-BARS, SCN, and TRM-LRGE macro- and meso-habitats to 1.98 m/s in ISB-CHNBs. Water temperatures ranged from 21.2-26.4 C in segment *25* and 26.0-28.7 C in segment *27*. Cobble substrates were only present in OSB and ISB macrohabitats in segment *25*, and OSB, ISB, and SCN macrohabitats in segment *27*. Gravel substrates were present in six of eleven macro- and meso-habitats in segment *25* and seven of ten macro/meso-habitats in segment *27*. Sand substrates were found in all macro- and meso-habitats except TRM-SMLL in segment *25*. Silt substrates were present in all macro- and meso-habitats except CHXO in segment *25* and ISB-CHNB in segment *27*.

A total of 3,071 fishes representing 39 taxa were collected during the 1996 field season (Table 81). The most abundant taxa collected were gizzard shad, freshwater drum, channel catfish, emerald shiner, and *Hybognathus* spp. The least abundant species collected were longear sunfish, ghost shiner, flathead chub, river shiner, fathead minnow, bigmouth buffalo, and walleye. Many more emerald shiners, sand shiners, goldeye, largemouth bass, blue catfish and sauger were collected in segment *25* than in segment *27*.

Eighteen of the 23 target benthic taxa were collected in section *9* in 1996. Benthic taxa not collected in 1996 were pallid sturgeon, blue sucker, white sucker, shorthead redhorse, stonecat, and burbot. Also, flathead chub, fathead minnow, bigmouth buffalo, and walleye were represented by one individual each (Table 81). A flathead chub was collected in segment *25* downstream from Jefferson City, MO, in an ISB-BARS mesohabitat in the bag seine. The fathead minnow was also collected in the bag seine in an ISB-BARS mesohabitat, but it was collected in segment *27*. The bigmouth buffalo was collected in segment *27* in an ISB-POOL with a stationary gill net. The walleye was collected in segment *25* in an ISB-BARS mesohabitat with a bag seine. Catch rates for the benthic fish guild were variable (Table 82). Standard deviations for these catch rates were high, indicating clumped distributions in each macrohabitat.

Twenty-two non-target species were collected during 1996 (Table 81). Most were uncommon (represented by <20 individuals). The five most abundant, non-benthic fishes collected were gizzard shad, goldeye, red shiner, shortnose gar, and bluegill. Gizzard shad

Table 81. Total numbers and mean total length (mm) (± 1SD) for fish species collected in Missouri River study section 9 (segments *25*, rkm 354-209/rmi 220-130, and *27*, rkm 80-0/rmi 50-0) in July, August, and September 1996. An * indicates the species is a target benthic fish.

Taxa	Segment *25*	mean total length (± 1 SD)	Segment *27*	mean total length (± 1 SD)	Total
Gizzard shad	347	64 (71)	1141	NA	1488
*Freshwater drum	107	55 (42)	148	51 (51)	255
*Channel catfish	121	52 (43)	133	59 (87)	254
*Emerald shiner	182	32 (6)	16	31 (5)	198
**Hybognathus* spp.	84	32 (5)	51	24 (4)	135
*Flathead catfish	46	160 (116)	55	192 (122)	101
*Common carp	39	421 (105)	51	384 (123)	90
Goldeye	67	242 (134)	14	124 (102)	81
*Blue catfish	57	51 (36)	23	84 (138)	80
Red shiner	38	34 (8)	42	38 (9)	80
*River carpsucker	22	148 (160)	24	346 (113)	46
Shortnose gar	32	455 (87)	13	528 (71)	45
Bluegill	29	76 (9)	15	35 (9)	44
Silver chub	15	40 (7)	13	35 (12)	28
*Sand shiner	22	NA	1	NA	23
Longnose gar	6	669 (138)	10	480 (131)	16
White crappie	9	101 (121)	4	42 (9)	13
Striped bass	5	210 (159)	7	94 (39)	12
*Shovelnose sturgeon	6	393[a] (218)	6	338[a] (221)	12
Largemouth bass	11	169 (131)	0		11
*Sicklefin chub	4	30 (5)	5	57 (16)	9
White bass	2	77 (25)	4	82 (7)	6

Table 81. Continued.

Taxa	Segment 25	mean total length (± 1 SD)	Segment 27	mean total length (± 1 SD)	Total
*Smallmouth buffalo	2	331 (1)	4	319 (25)	6
*Sauger	6	209 (120)	0		6
Mosquitofish	3	29 (6)	2	23 (10)	5
Speckled chub	2	39 (19)	3	28 (1)	5
Bluntnose minnow	2	35 (3)	1	61	3
Green sunfish	1	29	2	36 (8)	3
Orangespotted sunfish	0		3	41 (4)	3
Spotted bass	0		3	64 (39)	3
Suckermouth minnow	2	37 (1)	0		2
Bighead carp	0		2	29 (3)	2
*Sturgeon chub	1	73	1	31	2
*Walleye	1	97	0		1
*Bigmouth buffalo	0		1	527	1
*Fathead minnow	1	32	0		1
River shiner	0		1	36	1
*Flathead chub	1	49	0		1
Ghost shiner	0		1	47	1
Longear sunfish	1	102	0		1
Totals	1,274		1,797		3,071

NA-length information not available at time of this report.
[a] -fork length used on this species

Table 82. Catch per unit effort (±1SD) of all benthic fish collected in 5 gears and 6 macrohabitats in 2 river segments (segment *25*=rkm 354-209/rmi 220-130, and segment *27*=rkm 80-0/rmi 50-0) in the Lower Missouri River, MO in August and September, 1996. NU means the gear is not used in that macrohabitat. Bag seine CPUE = #/half circle haul, electrofishing CPUE = #/min, gill net CPUE = #/hour, and benthic trawl and trammel net CPUE = #/100 m.

Habitats (Segment)	Bag seine	Electrofishing	Gill net	Benthic trawl	Trammel net
CHXO (25)	NU	NU	NU	0.20 (0.30)	0
OSB (25)	NU	3.80 (3.14)	NU	0.07 (0.15)	0.0
ISB (25)	22.0 (14.21)	1.60 (1.40)	0.20 (0.18)	1.40 (1.64)	0.13 (0.30)
SCC (25)	38.0 (9.90)	NU	NU	5.08 (8.80)	0.0
SCN (25)	31.00 (**)	NU	0.0	NU	NU
TRM (25)	NU	25.1 (19.66)	0.16 (0.36)	2.67 (**)	0.0
CHXO (27)	NU	NU	NU	0.0	0.0
OSB (27)	NU	0.91 (0.40)	NU	0.27 (0.59)	0.0
ISB (27)	17.1 (21.42)	0.56 (0.26)	0.19 (0.28)	0.33 (0.56)	0.20 (0.45)
SCC (27)	3.50 (3.53)	NU	NU	3.15 (2.37)	0.0
SCN (27)	14.13 (22.63)	NU	1.47 (2.51)	NU	NU
TRM (27)	NU	0.78 (0.38)	0.51 (0.32)	NU*	NU*

* No large tributary mouths in segment 27 to be sampled with trammel nets and the benthic trawl.
** No standard deviation because sample size was 1.

were the most abundant species collected. Electrofishing catch rates were 16.40/min (± 1 SD=5.21) in TRMs, 0.06/min (± 1 SD=0.07) in ISB-STPSs, and 0.01/min (± 1 SD=0.03) in OSBs in segment *27*. Goldeye were common in both segments, but more were collected in segment *25*. Electrofishing catch rates in segment *25* were 0.20/min (± 1 SD=0.20) in TRMs, 0.04/min (± 1 SD=0.07) in ISBs, and 0.03/min (± 1 SD=0.03) in OSBs. Red shiner were the third most abundant non-target species collected. Bag seine catch rates were 1.25/haul (± 1 SD=0.50) in SCN and 0.50/haul (± 1 SD=0.35) in ISB-BARS in segment *27*. Shortnose gar were the fourth most abundant non-benthic species collected. Gill net catch rates in segment *25* were 2.20/hour (± 1 SD=2.39) in TRMs and 2.00/hour (no SD, sample size, N=1) in SCN. Gill net catch rates in ISB-POOLs were 0.0/hour (± 1 SD=0.0) in both segments. In segment *27*, gill net catch rates were 0.11/hour (± 1 SD=0.19) in TRMs. More bluegill were collected in segment *25* than in segment *27*. Electrofishing catch rates in segment *25* were 0.33/min (± 1 SD=0.43) in TRMs. No bluegill were collected in OSB and ISB macrohabitats with this gear. Similar to bluegill, white crappie and largemouth bass were only collected in TRM macrohabitats. Most individuals were large enough to interest anglers (Table 81).

Meetings/presentations. - The Missouri Coop Unit presented seven technical presentations in 1996. Two were presented at benthic fish consortium bi-annual workshops. Information presented at the June workshop included SOP testing/preliminary data collection, floodplain investigations, and hoop net evaluations. The November workshop focused on data and experiences from the first formal field season and included total numbers of target benthic fishes, physical characteristics in each macrohabitat, population size structure of common species, and additional hoop net evaluations.

The benthic fish project overview was also presented four times this year. An oral format was used at the Missouri Department of Conservation's Big Rivers/Catfish Meeting in January in Columbia, MO, the June "Planning and Evaluation Workshop: Contaminants in the Mississippi River Basin, National Biological Services, Biomonitoring of Environmental Status and Trends (BEST) Program," and twice for the Missouri River Natural Resources Committee. All presentations were information exchanges with other river biologists.

The benthic fish overview talk was also put into a poster format and presented at the Midwest Fish and Wildlife Conference in Omaha, NE in December. In addition to overview material, some preliminary data were summarized and presented. This included benthic fish presence/absence data, total numbers of sicklefin chub, shovelnose sturgeon, channel catfish, and flathead chubs, and depth, velocity, water temperature, and turbidity in CHXOs across 18 study segments.

Acknowledgments. - We are extremely greatful to our four field technicians, Mike Baird, Steve Intelmann, Eric Roberts, and Jose Oseguera for providing exceptional assistance in 1996.

Section: Database Management and Data Analyses

Mark Wildhaber (Quantitative Ecologist) and Linda Sappington (QA/QC Officer)

Midwest Science Center

Midwest Science Center (MSC) staff participate as Principal Investigators and provide technical support to the MRBFC. Thus no discussion concerning study area, preliminary/additional sampling or field sampling is applicable.

Standard operating procedures. - MSC (i.e., Linda Sappington) is responsible for overall coordination of Standard Operating Procedures (SOPs), and SOP document editing through use of a Quality Assurance Plan. This plan is vitally important for assuring overall success of research. By developing a series of SOPs, collection and assimilation of research data is insured of providing comparable, defensible results. The six CRUs, MTFWP, and MSC developed SOPs to meet research objectives using the Environmental Protection Agency' s guidelines for SOPs. All SOPs were peer reviewed and agreed upon by MRBFC participants for validity, accuracy, and effectiveness associated with the overall study design to ensure comparable observations for all parameters measured. A SOP manual was assembled (i.e., 1996 Standard Operating Procedures to Evaluate the Population Structure and Habitat Use of Benthic Fishes along the Missouri River (Sappington et al., 1996) . This manual contains the SOPs pertaining to Study and Sampling Design, Fish Collection and Identification, Habitat Characteristics, Database Design and Coding Instructions, Pallid Sturgeon Incidental Catch guidelines and Chain of Custody procedures (Table 4).

MSC (i.e., Mark Wildhaber) is also responsible for assisting in overall study design development, statistical analysis documentation, conducting project level analyses, and new analytical techniques development that would improve data interpretation.

SOPs developed for data analyses in 1996, include five critical areas: 1) experimental design, 2) fish attributes which encompass community and population structure and individual fish characteristic parameters, 3) physicochemcial parameters, 4) hypotheses, and 5) statistical analyses (Wildhaber 1996) (Table 4).

The experimental design uses a stratified random sampling design to sample benthic fish populations in the Missouri River. Strata are the six macrohabitats chosen for sampling with segments being the experimental block in which these strata are randomly sampled. The stratified random design is effective because of: 1) the ability to assure that what has been defined as the most critical, common macrohabitats found in segments are adequately sampled; and 2) the enhanced ability to assess differences in segments based on these common, critical macrohabitats by accounting for differences in macrohabitat types and thus decreasing the error term used to evaluate segment differences.

Fish community attributes of targeted benthic fish species are relative abundance and species richness. Since different macrohabitats require different sampling gear and different gears are more effective for certain fish species, the assessment of relative abundance among segments includes the use of two or three sampling gears for each macrohabitat. Difference in sampling effectiveness of different gears requires each gear to be analyzed seperately. Comparisons of relative abundance within macrohabitat types with different mesohabitat types, among macrohabitat types, and among segments over all macrohabitat types requires the use of a weight-of-evidence approach based on catch-per-unit-effort (CPUE). A possible alternative to the weight-of-evidence approach is conversion to catch-per-unit-area (CPUA). The conversion to CPUA will allow for combination of data from various sampling gears in a form that should adequately represent each macrohabitat sampled.

Species richness refers to the total number of fish species taken in a segment of the river and does not include hybrids. Standardization of macrohabitats, gears, and sampling effort for all segments of the Missouri River and the number of macrohabitat replicates sampled should provide for a fairly accurate measure of species richness that can be used to make valid segment comparisons. In order to validate this assumption the method of rarefaction will be used to account for differences in the number of fish caught in a segment in order to effectively assess species richness when sample sizes differ.

Population structure is the size and age group distribution of each species from the list of target benthic fish. Parameters being assessed in this study are length and weight distributions, young-of-year (YOY) and age-1 recruitment to gear, and ratio of YOY to age-1. The unit of sampling effort for length and weight comparisons is the macrohabitat since the combination of multiple gears used in each macrohabitat is designed to, as much as possible, sample the entire fish population within a macrohabitat; recruitment comparisons will be made at the segment level.

Individual fish characteristics that will be assessed in this study include growth and body condition. For growth, emphasis will be on benthic species for which aging structures are collected. Growth analyses include average growth per year both in length and weight as well as back-calculated from aging structures. Body condition will be analyzed in terms of relative weight for those species for which standard weight equations are available or can be developed; for species which no relative weight equation is available, relative condition factor will be calculated.

Physicochemical factors are measured to describe the physical environment within which fish are collected. These physicochemical variables are measured in an attempt to understand the relationship between fish attributes and the physical environment.

In formulating hypotheses that can be tested using appropriate statistics, the standard procedure is to state a null hypothesis that can be rejected at a given level of confidence (i.e., alpha); for this study alpha < 0.05. By using alpha < 0.05 there will be a 1 in 20 chance that any rejection of a null hypothesis observed could have randomly occurred. Power analysis (i.e., Beta) will also be used in support of any null hypothesis that cannot be rejected using alpha < 0.05; for this study Beta=0.8. A Beta=0.8 translates into a 1 in 5 (i.e., 1 - Beta = 0.2 Type II error) chance that a null hypothesis was accepted when in actuality it should have been rejected. For accepted null hypotheses, power analysis will allow for estimation of how large observed differences would have had to be in order for a null hypothesis to be rejected; concurrently, how many more samples would have been necessary in order to reject any such null hypothesis will be estimated.

As a result of the study design there are a large number (i.e., > 150 for the combined benthic fish group alone) of possible null hypotheses that could be tested. It must be kept in mind that the amount and quality of data that is actually collected, despite the use of an effective sampling design, will determine which of these null hypotheses can be tested.

Statistical analyses used in this study require several steps and numerous test procedures. Since the focus will be on parametric techniques, normality and homogeneity of variance will be tested and appropriate transformations will be used if normality and homogeneity are not met. Parametric analyses will include two-way analysis of variance (ANOVA), two-way multivariate analysis of variance (MANOVA), principal components analysis (PCA), stepwise regression, and correlation. If parametric assumptions can not be effectively met then rank ANOVA or permutations techniques will be used. When a large number of analysis level observations are zero, nonparametric tests will be used to an inability to meet parametric test assumptions.

Statistical analyses. - Many hypotheses listed in the statistics SOP may not be testable which is apparent from analyses done for this report. The inability to test many of the hypotheses is due to the, as expected, large number of zero catch samples for individual fish species or all species combined. Main limitations in statistical analyses occur in relation to hypotheses concerning individual fish species at less than the segment level. Low numbers of certain fish species overall and within certain macrohabitats indicate that many hypotheses below the segment level for those species will never be testable in this study even with a massive increase in sampling effort. At the same time, some species which show obvious upper river/lower river presence/absence do not require statistical analyses to say there are differences between upper and lower river populations. Also, balance in the number of samples collected in each segment allows for lifting the requirement of testing for homogeneity of variance; however the normality assumption must be met before proceeding with parametric tests.

Database development. - A relational database structure was developed to ensure ease of combining all information collected with minimal effort, by following clear and concise instructions for recording results. A fish nomenclature and species code list was generated along with standard formatted data sheets for habitat and fish measurements. A contractor was hired for data formatting and entering data to insure accuracy at minimal cost to the Consortium.

Meetings/presentations. - MSC participated in all MRBFC workshops in 1996 by facillitating development of statistical procedures, actual data analyses, cordinating SOP development and review, and teaching Consortium members data recording procedures and outlining Quality Assurance guidelines. Dr. Wildhaber conducted the statistics workshop in April, specifically for outlining the statistics SOP. MSC (i.e., Linda Sappington) participation, in June 1996, consisted of leading a discussion on coordination of SOP review comments and an intensive course designed for Consortium participants on data recording and Quality Assurance guidelines associated with data recording. MSC (i.e., Linda Sappington) also acted as focal point for raw data sheet collection, coordinator of data input with contractor, redistributor of research data to participants for checking and verifying and by initiating contact with USGS for retrieving river stage information for correlation with fish and physicochemical measurements. Finally an enhanced version of the statistics outline was presented by Mark Wildhaber. This outline included comments received at the April workshop and through correspondence with other project PIs. At the November workshop, Linda Sappington updated participants on data and associated costs. She also assisted in initial SOP modifications. Dr. Wildhaber presented the full statistics SOP, preliminary data analyses, and proposed new analytical techniques. He also analyzed data for presentation with the Benthic Fish Poster given at the Midwest Fish and Wildlife Conference (Table 7), and for this annual report. Finally, he gave interpretative guidance to annual report analyses.

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

AGENCIES

COE	Corp of Engineers
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
MSC	Midwest Science Center
MTCRU	Montana Cooperative Fish and Wildlife Research Unit
MTFWP	Montana Department of Fish, Wildlife, and Parks
SDCRU	South Dakota Cooperative Fish and Wildlife Research Unit
USFWS	United States Fish and Wildlife Service

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

Discrete Macrohabitats:

SCC	Secondary Channel: Connected
SCC-DEEP	Secondary Channel Connected: Deep
SCC-SHLW	Secondary Channel Connected: Shallow
SCN	Secondary Channel: Non-Connected
TRM	Tributary Mouth
TRM-LRGE	Large Tributary Mouth
TRM-SMLL	Small Tributary Mouth
WILD	Wild Card Macrohabitat

Appendix A. Continued.

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*
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 punctatus*
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*

Appendix A. Continued.

Code	Common name	Scientific name
GSCP	Grass carp	*Ctenopharyngodon idella*
GSOS	Green sunfish x Orangespotted	*Lepomis cyanellus* 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*
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	*Polyodon 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	*Carpiodes carpio*
RVRH	River redhorse	*Moxostoma carinatum*
RVSN	River shiner	*Notropis blennius*

Appendix A. Continued.

Code	Common name	Scientific name
SDBS	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 *vitreum*
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*
SNSG	Shovelnose sturgeon	*Scaphirhynchus platorynchus*
SNSN	Sand shiner	*Notropis stramineus*
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*
YOYF	Age-0 fish (young-of-the-year)	*Unidentified*
YWPH	Yellow perch	*Perca flavescens*

Appendix B. Hypothetical maps of Missouri and Lower Yellowstone River macrohabitats.

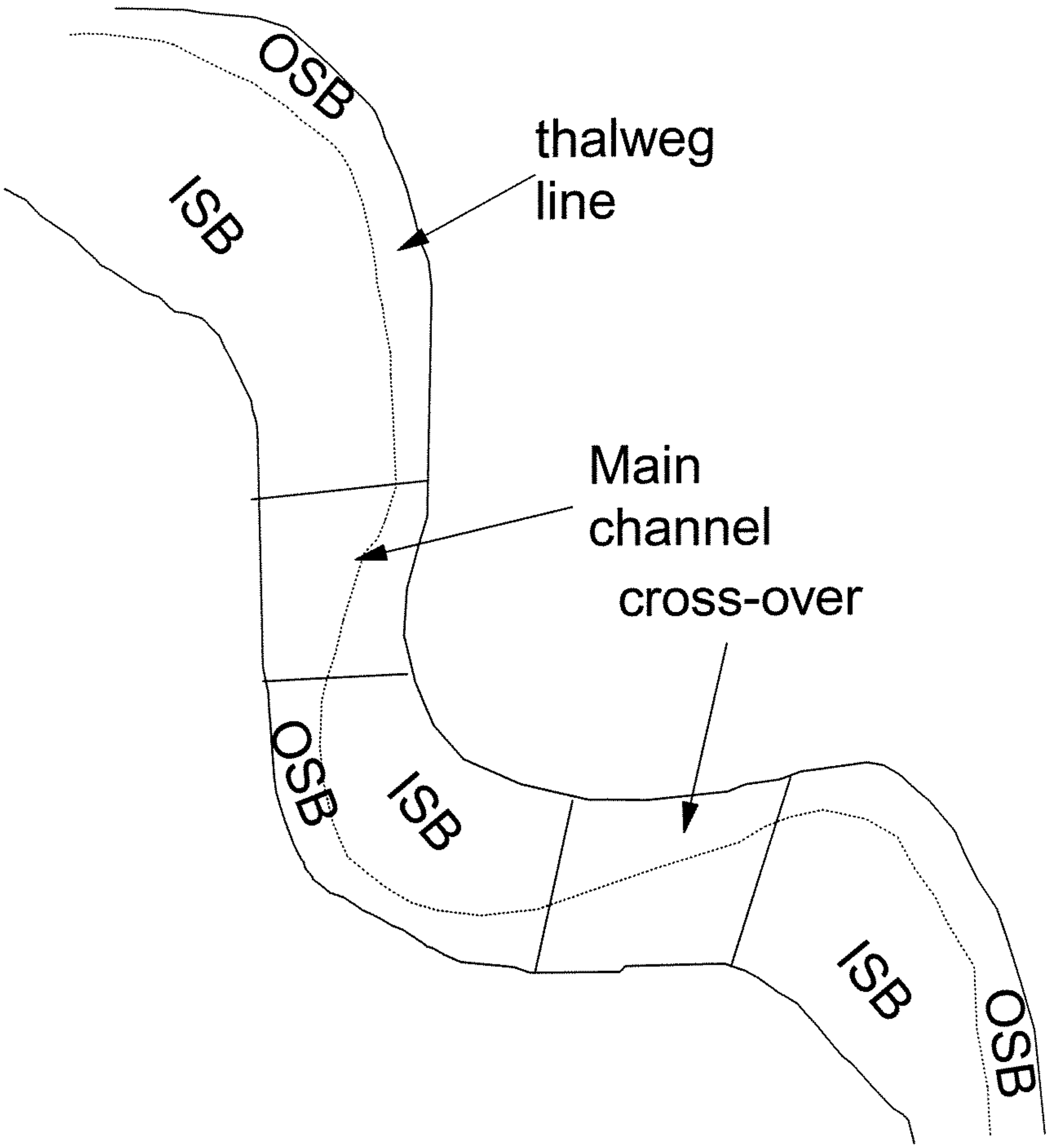

Figure 1. Hypothetical map of the Missouri or Lower Yellowstone River showing boundaries of continuous macrohabitats; main channel crossovers, outside bends (OSB), and inside bends (ISB).

Appendix B. Continued.

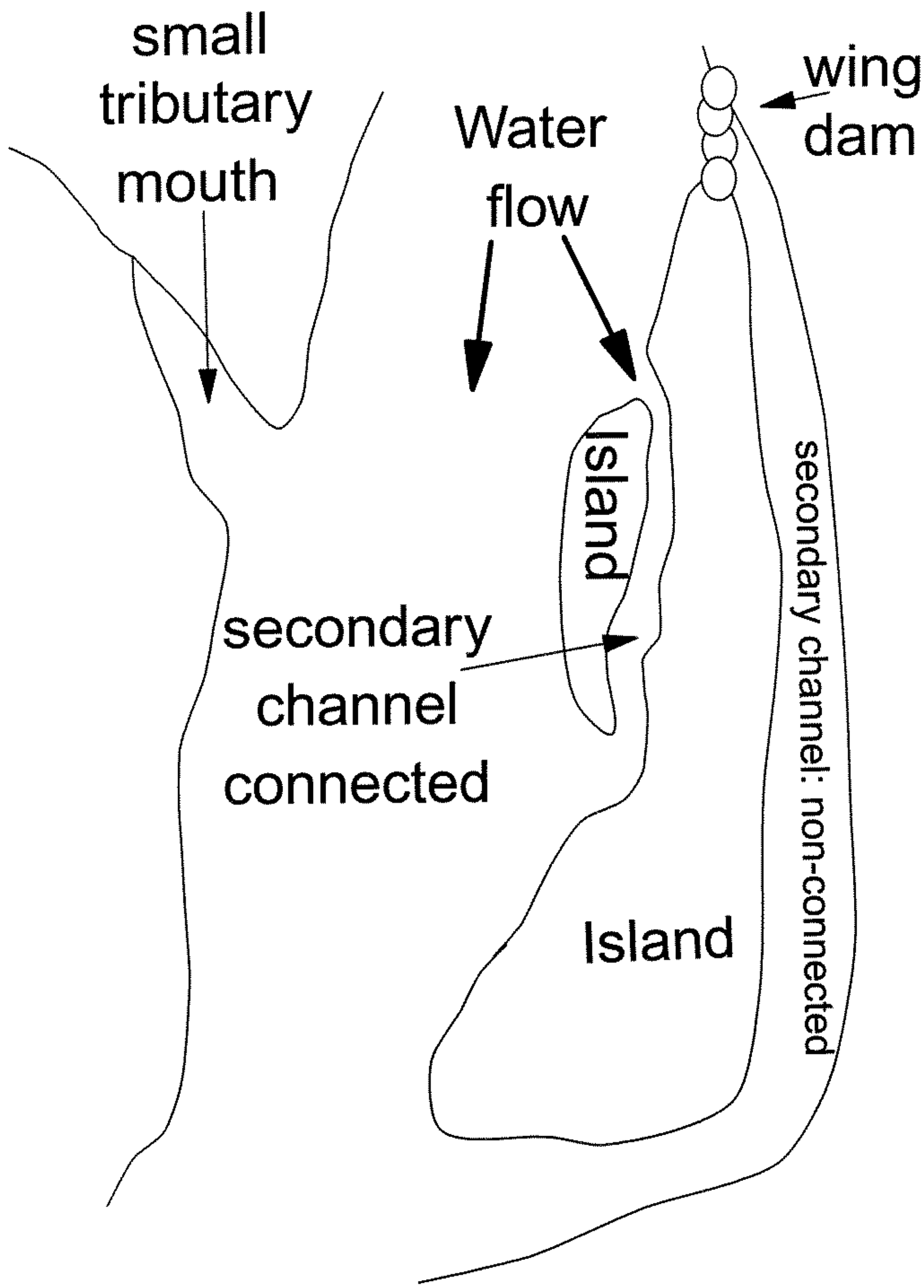

Figure 2. Hypothetical map of the Missouri or Lower Yellowstone River showing discrete macrohabitats; tributary mouth, secondary channel:connected, and secondary channel:non-connected.