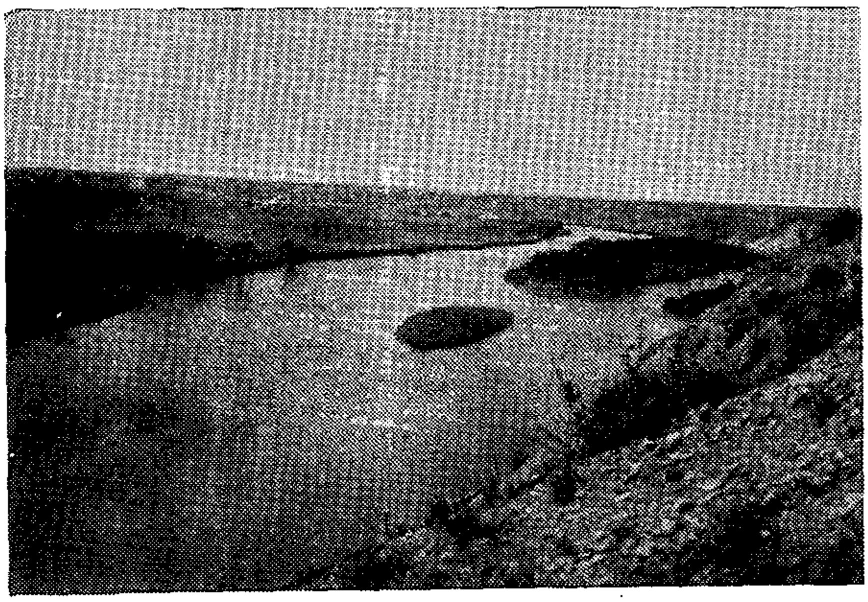
F-15-1

Assessment of Potential Fisheries Impacts Associated with the Milk River Water Supply Project

June 1, 1986



Prepared by:
Henry G. Drewes and Kent Gilge
Fisheries Biologists
Montana Department of Fish, Wildlife and Parks

Assessment of Potential Fisheries Impacts Associated with the Milk River Water Supply Project

June 1, 1986

Prepared by: Henry G. Drewes and Kent Gilge
Fisheries Biologists
Montana Department of Fish, Wildlife and Parks

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont.)

LIST OF TABLES

LIST OF TABLES (Cont.)

LIST OF FIGURES

LIST OF FIGURES (Cont.)

INTRODUCTION

The Milk River Water Supply Project proposed by the Bureau of Reclamation would divert water from the Missouri River near Virgelle, Montana, to the Milk River near Havre, Montana. The primary purpose of the project is to provide supplemental irrigation water to the Milk River Valley. Various projects designed to deliver additional water to the Milk River have been evaluated by the Bureau of Reclamation in recent years. The Virgelle-Milk canal is the alternative currently under consideration.

During years of below-normal precipitation and runoff, irrigators along the Milk River below Fresno Reservoir often suffer shortages. Under present conditions, the average annual water shortage is estimated to be about 23,000 acre-feet and is expected to increase for the following reasons (Information handout-Bureau of Reclamation Environmental Scoping Session - June 18, 1985): (1) Presently, Canada does not use its allotted water but does plan to use that allotment in the future, (2) the Bureau of Land Management is expected to develop more stock ponds, and (3) the Fort Belknap Indians are expected to increase the number of acres under irrigation. Bureau of Reclamation figures suggest these increased demands on the Milk River would create an average annual shortage of approximately 77,800 acre-feet. The proposed Milk River Water Supply Project would reduce the projected shortages in the Milk River.

Four alternative pumping sites for diverting water from the Missouri River near Virgelle, Montana, have been considered by the Bureau of Reclamation (Figure 1). The Virgelle site was the preferred site when this study originated, the additional sites were added after this time. Hence research efforts were concentrated at the Virgelle site. Four canal routes considered for the conveyance of pumped water to the Milk River are shown in Figure 2. An intense one-year study was conducted to ascertain the potential fisheries impacts, if any, associated with the Milk River Water Supply Project. The objectives of this study were:

Missouri River

1. To attempt to locate and monitor spawning sites of sauger, paddlefish, shovelnose sturgeon and other fish species in the immediate project area.

2. To determine species composition, abundance and periodicity of larval fish drift in and through the project area.

3. To describe the vertical and horizontal distributions of larval fish at the proposed project site.

4. To map the river current vectors and channel dimensions at and near the proposed project site and relate it to larval drift movements and orientation.

5. To relate dynamics of larval drift to possible impacts from location and operations of proposed pumping station.

6. To determine the occurrence and location of larval fish production in the study area.

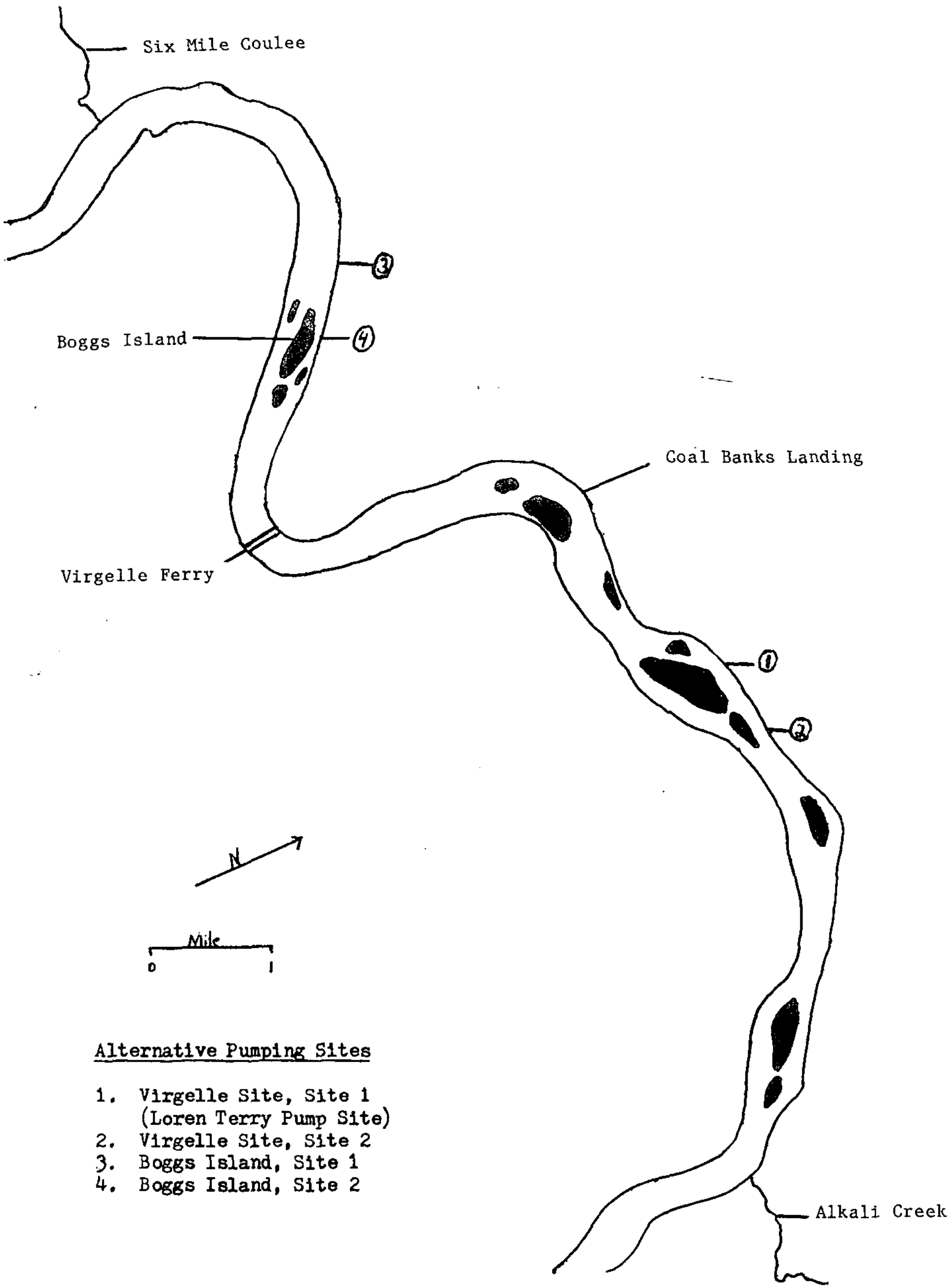


Figure 1. Map indicating the location of the four alternative pumping sites on the Missouri River.

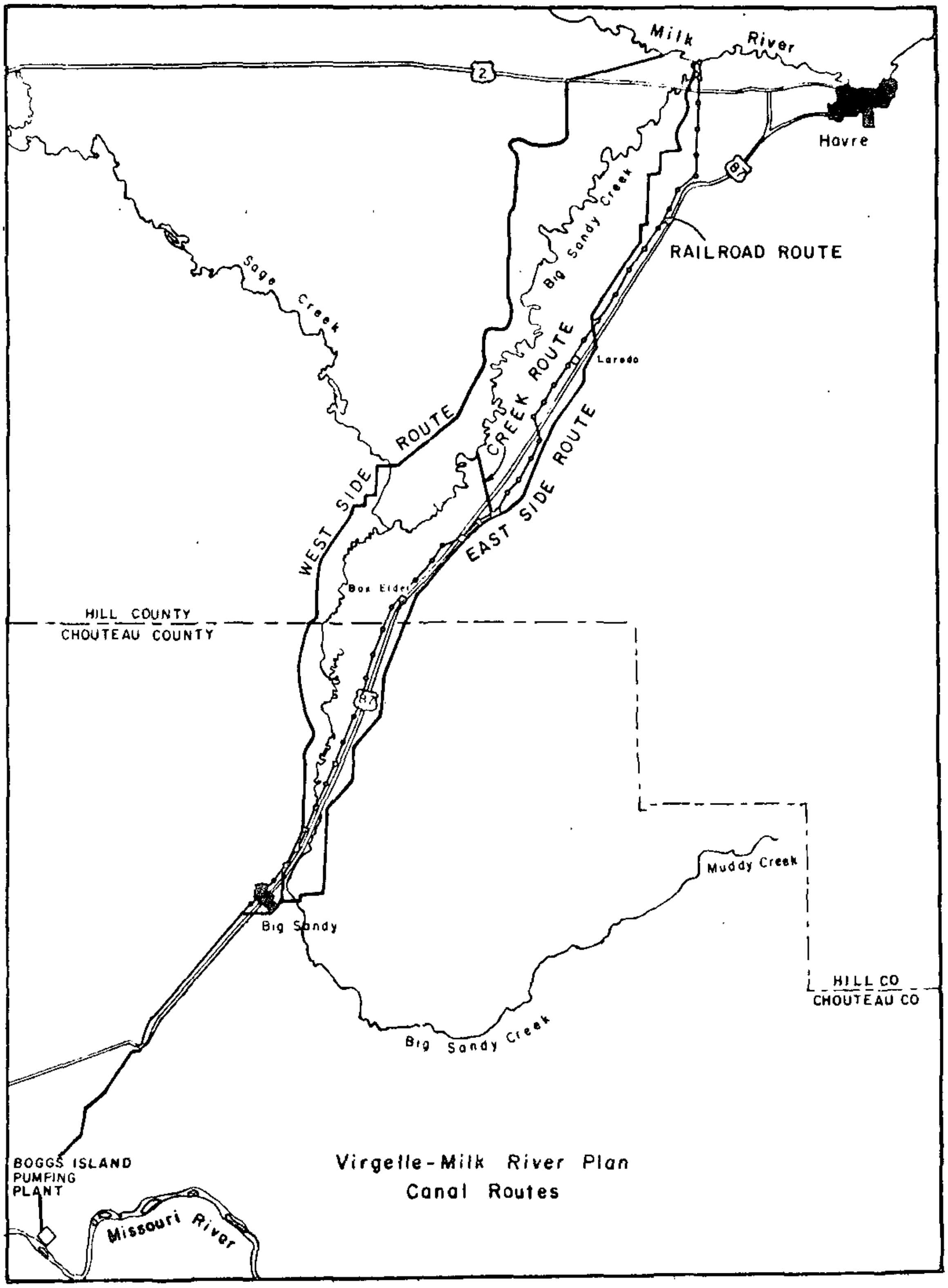


Figure 2. Map indicating the four alternative canal routes for the Milk River Water Supply Project (Source: Bureau of Reclamation public hearing in Big Sandy December 3, 1985)

7. To determine the project area's nursery habitat value for such sport fish as sauger, shovelnose sturgeon, and channel catfish.

Big Sandy Creek

1. To determine the status of resident fish populations in Big Sandy Creek.

2. To determine the importance of Big Sandy Creek as a spawning and rearing area for Milk River fish populations.

STUDY AREA

Missouri River

The Missouri River exists as a free-flowing river from Morony Dam to Fort Peck Reservoir. This 207 mile reach is the last major free-flowing portion of the Missouri River. The extraordinary value of this resource warranted the inclusion of a 149-mile stretch from Fort Benton to Robinson Bridge, into the National Wild and Scenic Rivers System (U.S. Congress 1975a). Under provisions of the legislation, no dams may be built on any of the protected waters and specific protective regulations will be imposed on any new commercial development in designated areas surrounding protected waters (U.S. Congress 1975b). The law does allow minor diversion and pumping of water from the protected area for agricultural uses. Private landowners in the area can continue with traditional grazing, farming, recreational, and residential uses (U.S. Congress 1975b). The Missouri River from Morony Dam to the headwaters of Fort Peck Reservoir (Figure 3) has been designated as a Class I water by the Montana Department of Fish, Wildlife and Parks. This designation identifies those waters with the highest-value fishery resources (U.S.D.I. 1980).

A unique and environmentally sensitive aquatic ecosystem exists in the Virgelle Ferry-Little Sandy Creek reach of the Missouri River. Significant numbers of paddlefish are believed to spawn in this area. The paddlefish is a fish of special concern-Class A in the state of Montana and a dwindling resource nationwide (Hubert et al. 1984). Pallid Sturgeon have been sampled within the Virgelle Ferry-Little Sandy Creek portion of the Missouri. The pallid sturgeon is also a fish of special concern-Class A in Montana and is listed as a threatened species by the American Fisheries Society. Considerable populations of shovelnose sturgeon and sauger exist within this area. Moreover, this location is one of the most important spawning areas for fish fauna in general, within the entire middle Missouri River, as witnessed by the large numbers of larval fish sampled in past studies (Berg 1981).

Big Sandy Creek

Big Sandy Creek originates in the Bear Paw Mountains approximately 20 miles east of the town of Big Sandy. It flows southwesterly out of the foothills, then swings north to the Milk River entering about nine miles above the City of Havre, Montana. The Big Sandy Creek drainage courses through approximately three miles of mountains, 15 miles of foothills, and 80 miles of prairie before reaching the Milk River. Data was collected within the prairie portion only, as this section is expected to receive the greatest impact from the project. The study area for this assessment was limited to the lower 50 miles of Big Sandy Creek and contained two distinct reaches (Figure 4).

The upper reach, Box Elder to Highway 2, is approximately 48 miles long. It is typified by long shallow pools terminating in short riffles. It is a highly erosive reach evidenced by many high vertical banks. Riparian vegetation consists mainly of grasses with occasional patches of rose or snowberry. Pool bottom substrate is principally mud and sand while riffles contain considerable gravel and rubble.

The lower reach, Highway 2 to the mouth, is approximately two miles in length. Water depth and velocity in this reach are principally governed by the flow in

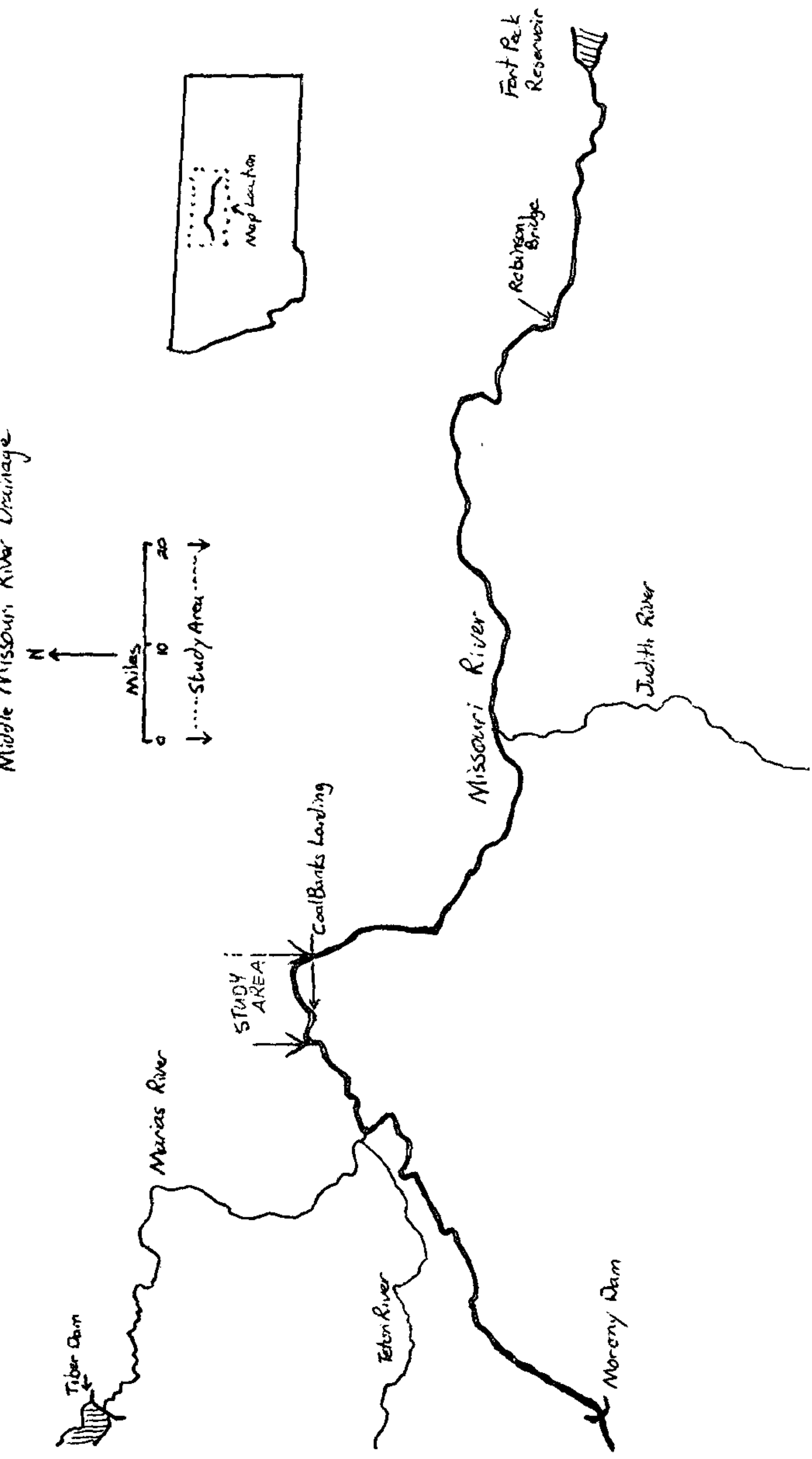


Figure 3. Map of the middle Missouri River drainage and study area.

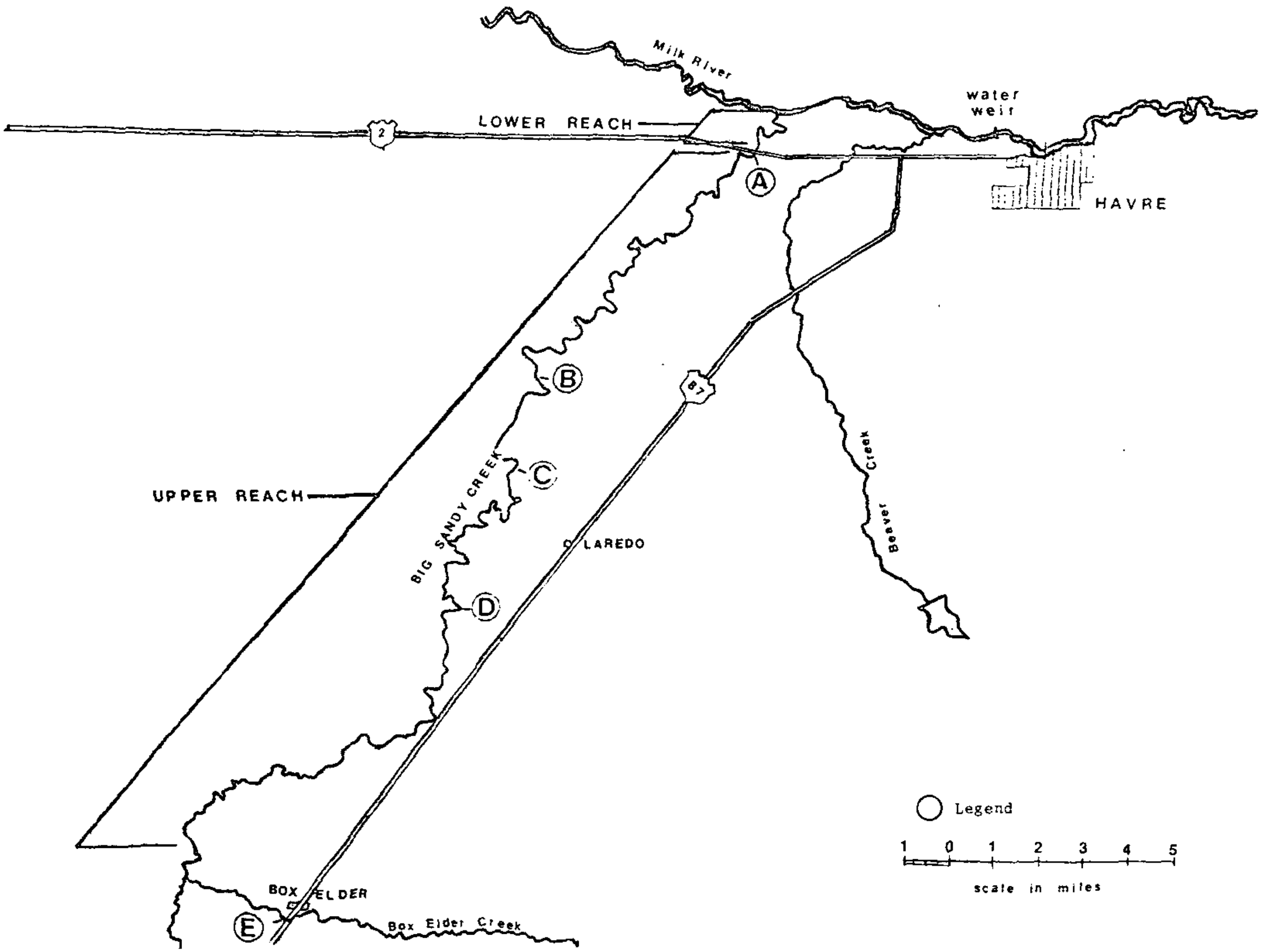


Figure 4. Map of Big Sandy Creek study showing reaches and locations of larval fish sampling stations.

the Milk River. Under high Milk River flows, the reach becomes a depositional backwater pool over a mile long. Under low Milk River flow conditions, this portion of the creek returns to the typical pool-riffle configuration.

Flow records on Big Sandy Creek are sporatic and incomplete. Records from 18 water years between 1927 and 1953 show a mean annual discharge of 13.8 cfs. The maximum flow recorded was 5,100 cfs in 1952. Flows in excess of 1,000 cfs have occurred at least three times since 1927. However, the duration of these large flows is rarely more than one week.

Heavy runoff in prairie streams most often occurs by rapid melting of deep snow cover, usually in combination with warm chinook winds and rain. Low elevation and lack of shading provide for rapid snow melt. Prairie streams like Big Sandy Creek generally do not receive the precipitation common to mountain areas. Consequently, heavy runoffs occur only once every 15-20 years in Big Sandy Creek. Peak flows occur between mid-March and mid-May.

Climatic conditions prior to and during the study period were unusual. The year prior to the study, 1984, recorded the lowest precipitation in almost 80 years. This was followed by a similar drought in 1985. Peak flows in the spring of 1984 and 1985 were 9.0 and 16.0 cfs respectively. No flow was recorded for much of the summer in the lower reach and the creek was reduced to a series of isolated pools. Therefore, the results of this study are not representative of the fishery conditions of Big Sandy Creek during normal flow years.

METHODS

Missouri River

Adult Fish

Pulsed direct-current electroshocking was used to locate and monitor spawning sites of sauger, paddlefish, shovelnose sturgeon and other fish species within the study area. Standard boat shocking techniques were utilized. A typical electroshocking run began at Six Mile Coulee and ended at Alkali Creek (Figure 5). The duration of an average electroshocking run was 3.5 hours. Electroshocking was conducted every two weeks from 17 April to 8 August 1985.

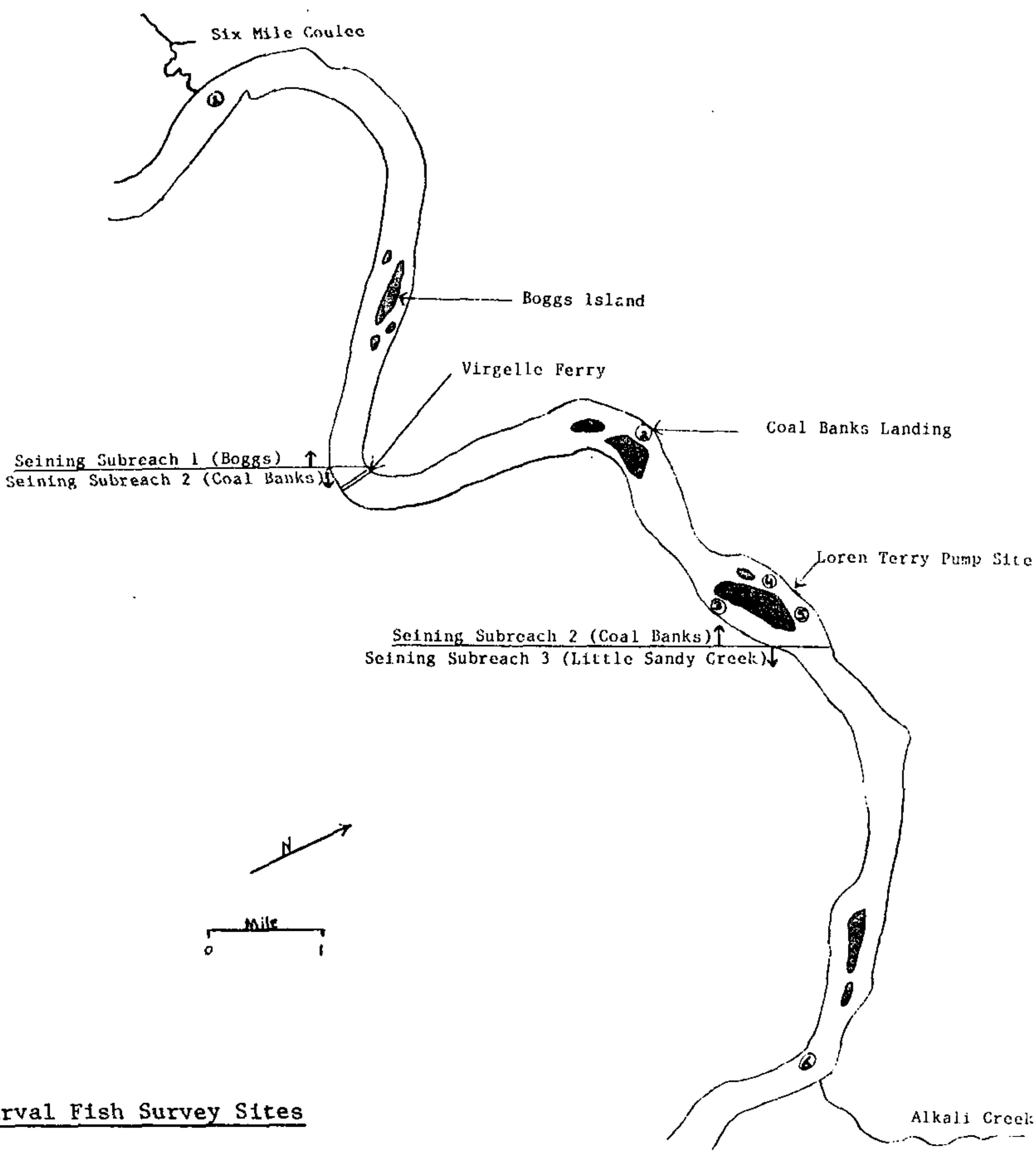
Relative abundances of fishes collected were recorded in terms of catch per unit effort (CPUE). One unit effort was defined as one hour shocking time. Sightings of shovelnose sturgeon were included in CPUE calculations and when possible, shovelnose were captured. Total length (TL) and weight were recorded for all game fish collected. Fork length (FL) was also recorded for shovelnose sturgeon. Analysis of variance was used to test for significant differences in length and weight between spawning and postspawn periods for shovelnose sturgeon and sauger.

Larval Fish

Longitudinal distribution and temporal abundance of fish larvae occurring within the study area were determined from larval fish samples collected on the surface at six survey sites (Figure 5). Weekly samples were collected during daylight hours from 9 May to 23 August. Vertical and horizontal distribution of fish larvae were determined adjacent to the Loren Terry Pump Site. Horizontal samples taken along this transect included a station approximately 50 feet from each bank and a mid-river station. Vertical samples were collected at the surface, mid-depth and off the bottom. Intensive larval fish samples were collected weekly from 10 May to 12 July. Diel changes in larval fish drift were determined on 11 June from mid-river samples collected at dawn, noon, dusk and midnight in the main channel adjacent to the Loren Terry Pump Site.

Larval fish samples were obtained using boat mounted, low speed, plankton-net samplers (Figure 6). Conical 0.5m diameter, 1.6m long Nitex nets (750 micron mesh) were used. Duplicate nets were fished during all larval fish sampling. For collecting surface samples nets were attached to anterior booms and weighted to insure the entire drift net was submerged. While sampling in this fashion the boat position in the river was maintained using the outboard. For vertical intense samples, the boat was anchored for stationary sampling. Drift nets were attached to anchored lines at appropriate depths.

The volume of water filtered was determined using General Oceanic flow meters (Model 2030) mounted on the front ring of the net and suspended at one third of the net diameter. Three-line, plastic coated, braided cable bridles were used to attach the nets to the suspension booms. Nets were fished for 15 minutes unless net clogging and meter fouling by filamentous algae became a problem. In the case of a single fouled meter, the volume recorded on the duplicate sample was recorded. In the event that both meters were fouled, the average volume for all samples collected at that sampling site was substituted for both nets.



<u>Larval Fish Survey Sites</u>

1. Six Mile Coulee
2. Coal Banks Landing
3. Bypass Channel
4. Upper Pump
5. Lower Pump
6. Alkali Creek

Figure 5. Location of the six larval fish survey sites and seining subreaches on the middle Missouri River, 1985. River width has been distorted to facilitate sketching.

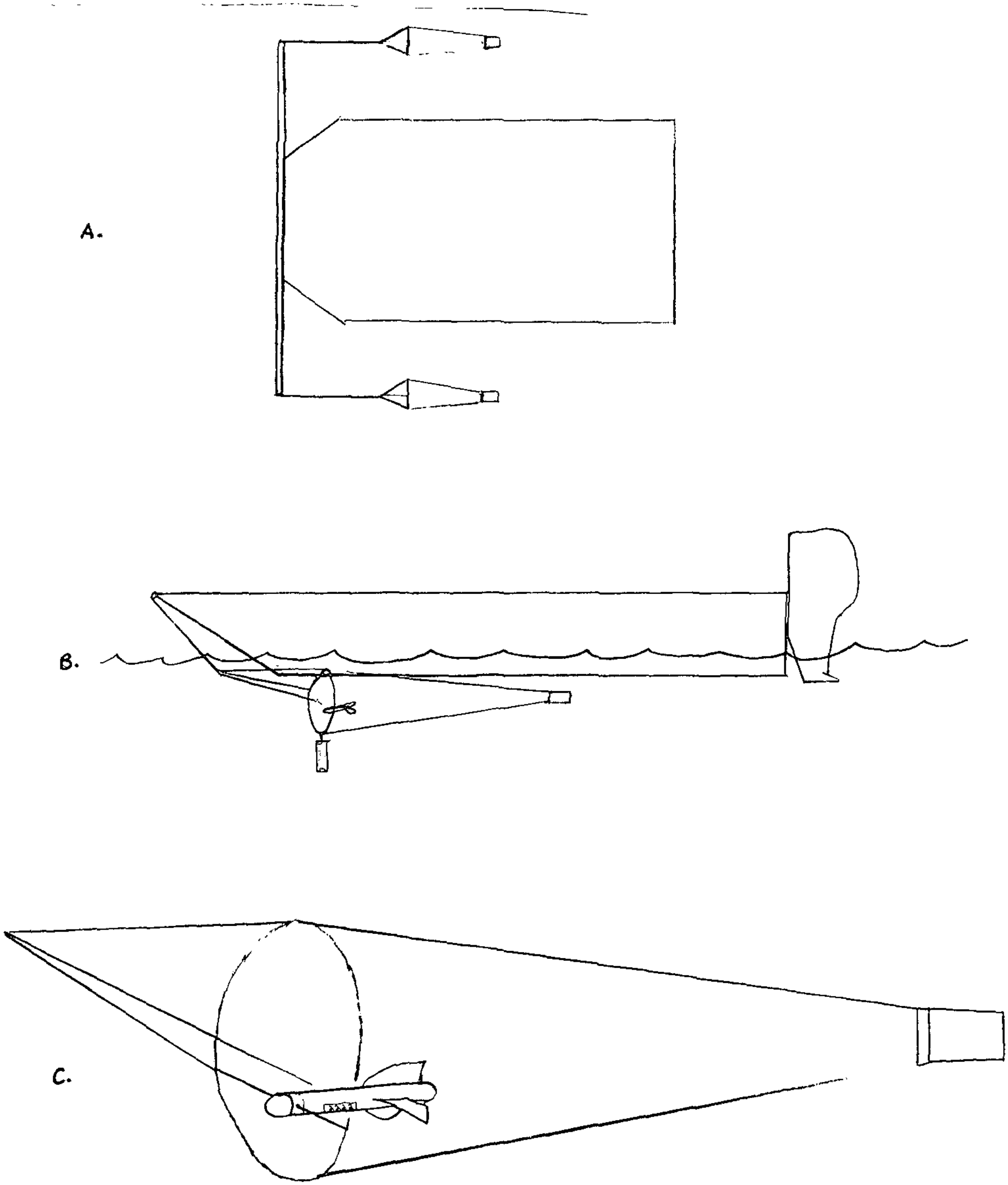


Figure 6. Top view (A) and side view (B) of vessel mounted, low speed plankton nets used to sample drifting fish larvae and bridle configuration with digital flow meter (C).

Samples were rinsed and preserved with 10 percent formalin colored with phloxine-B dye, for laboratory separation and identification. Larvae were identified to the lowest taxon practical using standard keys. For the purpose of this report a larval fish was defined as a fish with no development of pectoral fin rays. A reference collection was prepared and identification of specimens confirmed by Kent Gilge (MDFWP). The mean density was calculated for each pair of samples and treated as a single determination. The MSUSTAT statistical software package (Lund 1985) was used for statistic analysis. Analysis of variance was employed to test for differences within each taxa among sampling sites.

River current vectors were mapped to evaluate larval fish drift dynamics. A calibrated tag-line was suspended across the river adjacent to the Loren Terry Pump Site. The tag-line was used for vessel orientation across the channel. Vertical velocity profiles were taken at 25 foot intervals across the transect. At each position total depth was recorded and velocities determined at 1, 3, 5, 7, and 9 foot depths where applicable.

Velocities were determined using a General Oceanics digital flow meter (Model 2030) mounted on a steel rod (Figure 7). This apparatus was raised and lowered to desired depths from the bow of the boat. While holding the boat in position the device was lowered to the desired depth and the number of rotor turns recorded for a three minute suspension. Surface velocities measured using this instrument were checked with a Price AA current meter and found to be comparable (±5 percent). Velocity vectors were determined at low (4402 cfs @ Virgelle gaging station) and moderate (8804 cfs @ Virgelle gaging station) flow levels.

Young-of-the-Year and Forage Fish

Seining was conducted from early August through mid-September to identify important rearing areas. Young-of-the-year (YOY) fish and minnow species were sampled with a 50 x 4 ft. beach seine (1/8 in. square mesh). All possible shoreline habitats were seined. A standard seine haul was considered one unit effort when fully extended and pulled across approximately 50 feet of river bottom. Habitat type, species composition and abundance were recorded for each seine haul. A sub-sampling system was employed when large catches were obtained. In these instances total numbers were calculated based on a sub-sample comprising 10-25 percent of the sample volume.

Habitat types investigated were classified as being main channel border, main channel pool, side channel chute, side channel pool or backwater (Figure 8), as described by Gardner and Berg (1982) with one exception. For the purpose of this study a side channel was considered to be a channel diversion with up to 25 percent of the river flow. To better evaluate key rearing locations within the study area the river was divided into three subreaches (Figure 5). Seining data was analyzed by both river subreach and associated habitat type.

River Hydraulics and Dimensions

Mapping channel dimensions at the Loren Terry Pump Site was accomplished using the Wetted Perimeter (WETP) computer program. This program is described in detail by Nelson (1980). Three transects were established in the main channel and one in the associated bypass channel (Figure 9). Using standard surveying techniques, water surface elevations at several flows were measured with a level

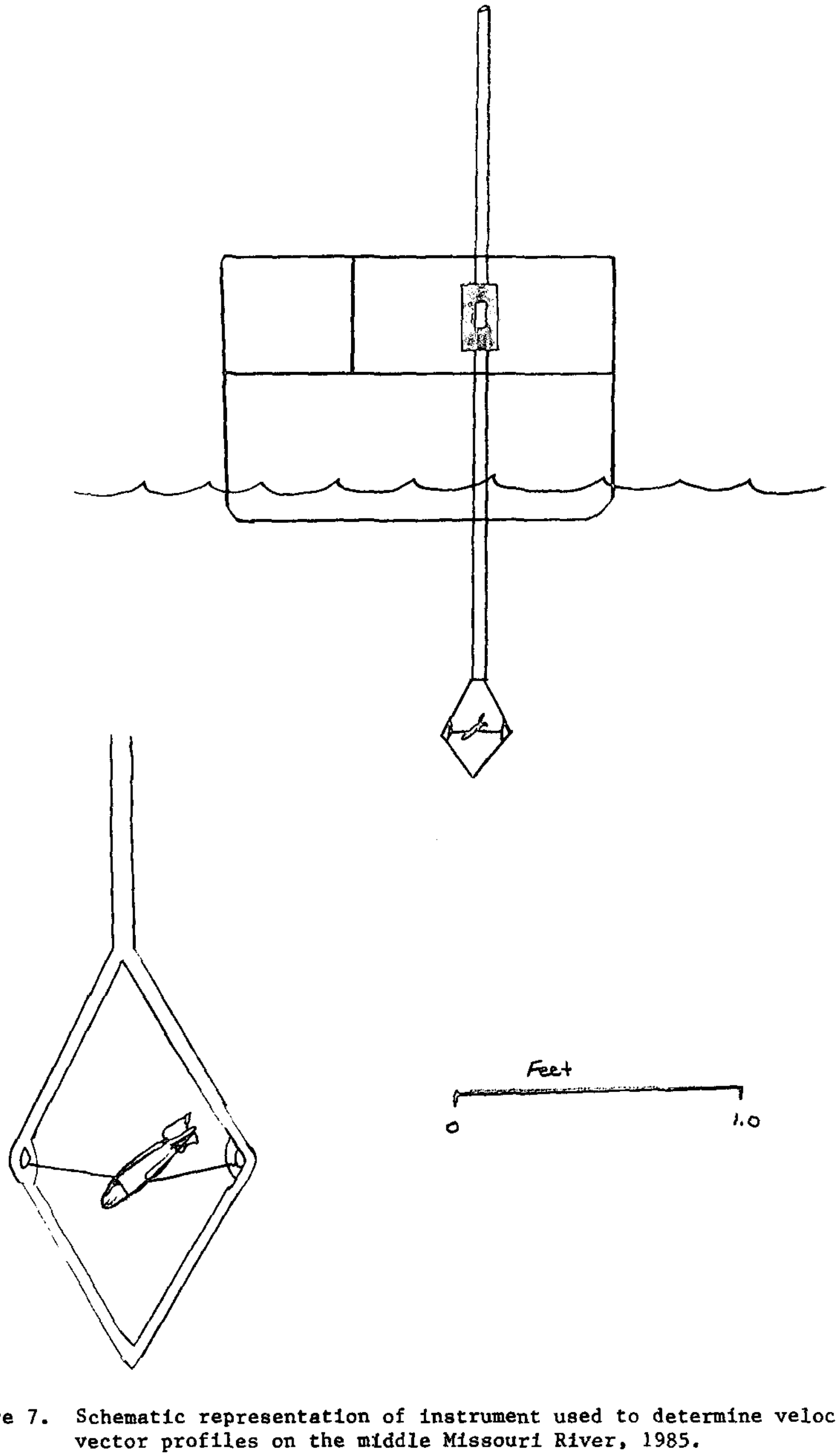


Figure 7. Schematic representation of instrument used to determine velocity vector profiles on the middle Missouri River, 1985.

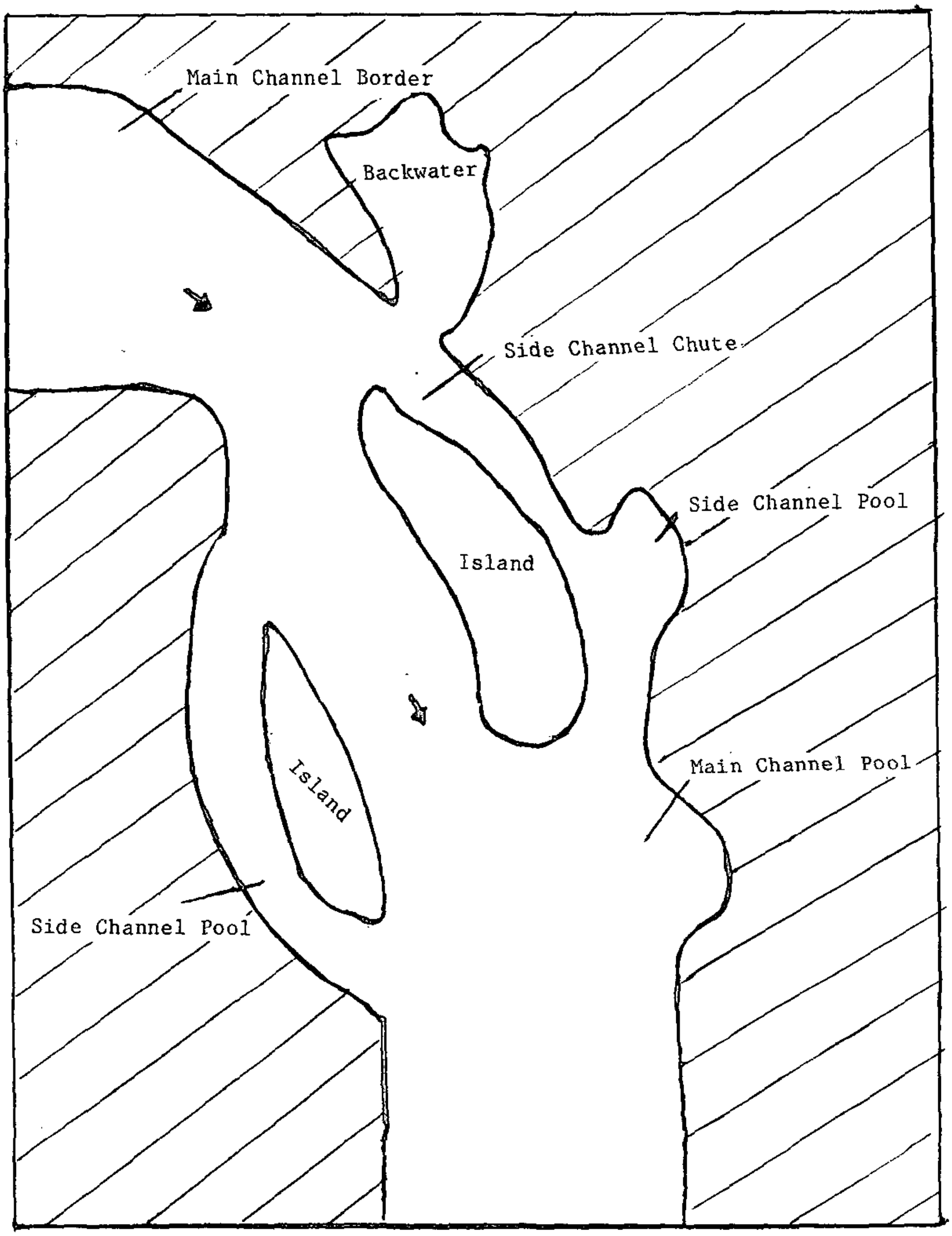


Figure 8. Diagrammatic representation of peripheral habitats seined in the middle Missouri River, 1985 (modified from Kallemeyn 1977).

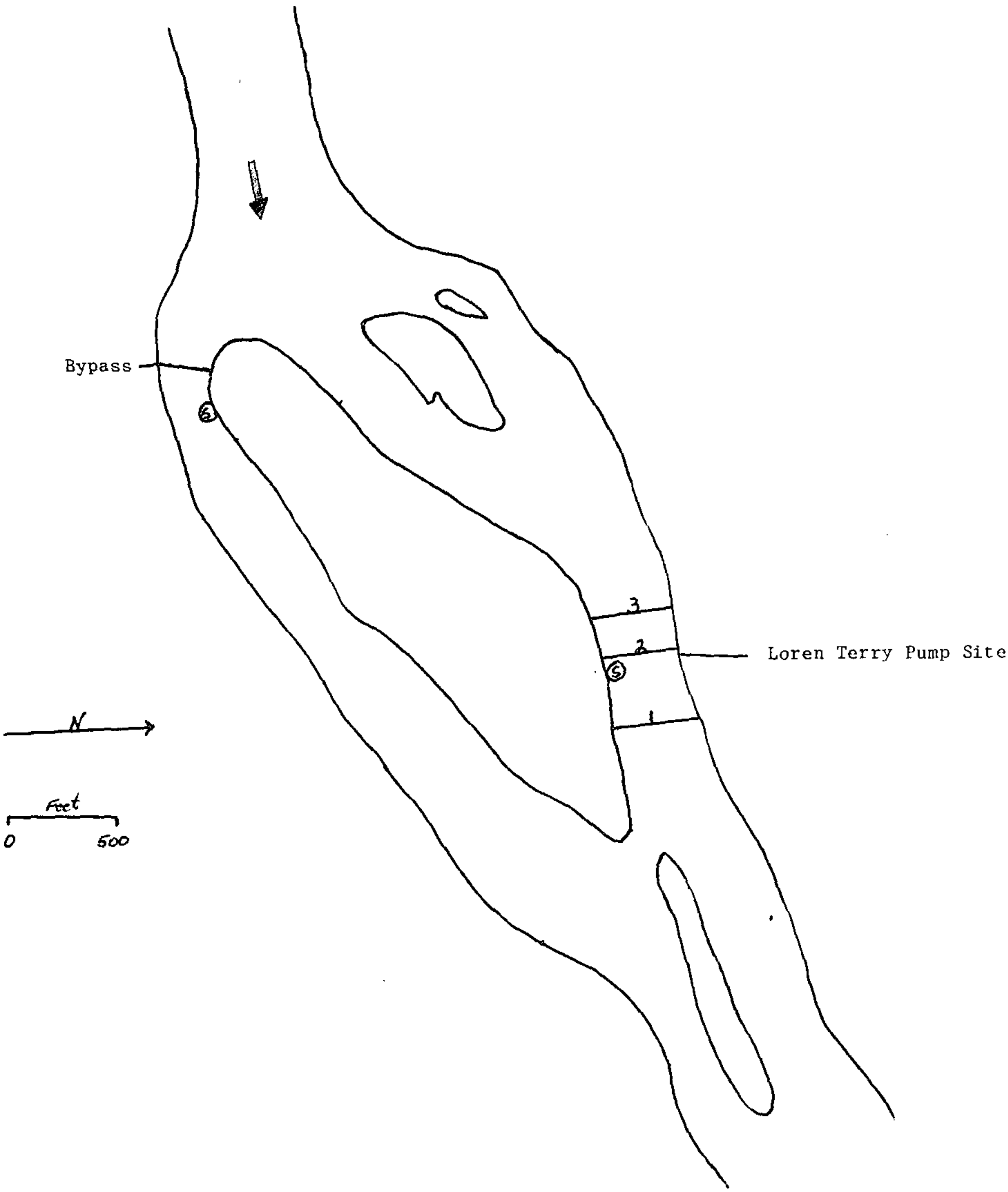


Figure 9. Detailed representation of the Missouri River adjacent to the Loren Terry Pump Site, including the location of Wetted Perimeter transects and staff gages(s).

and stadia rod. The channel profile was measured at low flow. A Lietz range finder (Model SD-5F) was used to determine distances and keep the boat on the transect line. Depths along the transect were obtained using a Raytheon graph recorder (Model DE-719B). Similar techniques were used by Graham and Penkal (1978) on the lower Yellowstone River, Montana.

Flows for the middle Missouri River in 1985 were obtained from the USGS gage at Virgelle. Provisional flow data from the Virgelle gage for the period October, 1984 through September, 1985 was obtained from the USGS. A thirty-day continuous recording thermograph was located just upstream from the Virgelle Ferry to monitor water temperature regimes during the 1985 field season. The quantity of water bypassing the main channel adjacent to the Loren Terry Pump Site was determined at various flows. A Price AA current meter and standard techniques described by Buchanan and Somers (1969) were used to measure the flow in the bypass channel at several river stage heights. Staff gages were placed in the main channel and in the bypass channel. Staff gage and flow data were used to develop a relationship between the flow at Virgelle and the quantity of water in the main channel at the Loren Terry Pump Site.

Big Sandy Creek

Larval Fish

Larval fish were sampled with a 0.5m diameter by 1.6m long Nitex plankton net (0.75 mm mesh). The net was fished in a stationary position in the swiftest portion of the flow. Water depth and velocity were determined at the orifice with a Price AA current meter and calibrated wading rod. The net was fished for a measured period of time, usually 30 minutes. These measurements were used to calculate volume of water sampled. All samples were collected during dawn-to-dusk hours. Samples were preserved in 10% Formalin and phloxine-B stain was added to aid in separating larvae from aquatic vegetation.

Adult and Juvenile Fishes

Several types of sampling gear were utilized to sample juvenile and adult fishes. A 25-foot x 5-foot x 1/4-inch mesh beach seine was utilized extensively early in the year prior to weed growth. The seine was stretched from bank to bank and hauled downstream until a suitable beaching area was found. Rocks, debris, and weeds often fouled the hauls and escapement was substantial at times. All fish were identified and counted except when large numbers of a particular species were sampled. In such cases a sub-sample was counted and an estimate made of the remaining catch. Sampling in the lower reach was conducted during two time intervals, early May and mid-July.

A mobile bank electrofishing apparatus was used in weedy areas. This unit consisted of a portable 4000-watt, 230-volt AC generator connected to a Coffelt VVP-15 rectifying unit and 250 feet of positive electrode cord. This system allowed 500 feet of stream to be electrofished before equipment had to be relocated.

The lower sampling station near the mouth was sampled with a boom-suspended electrofishing boat. The boat was maneuvered and propelled by a 7.5 hp outboard motor. The previously described power source and rectifying unit were utilized on the boat. The boom shocker allowed for greater flexibility in this deeper, wider portion of the creek. Sampling efficiency in the lower reach was best when Milk River flows were low, decreasing the depth of the backwater area in the Big Sandy Creek.

The lower reach was sampled in spring, mid-summer, and late summer by electrofishing. Higher water levels in the first two sampling periods lowered shocking efficiency and excluded beach seining. Excessive weeds in late summer hampered mobility and clogged the outboard and nets. Due to sampling inefficiency and escapement, quantitative measurements of forage fish populations in the lower reach were not attempted as the primary emphasis was placed on locating and capturing game fishes.

Northern pike and walleye captured by the various techniques were anesthetized with MS-222, measured to the nearest millimeter in total length and weighed to the nearest 10 grams (g). Northern pike greater than 25 cm were tagged with individually numbered Floy T-tags inserted near the base of the dorsal fin.

RESULTS

Missouri River

Adult Fish

Shovelnose sturgeon and sauger were the most abundant game fish species collected in 1985. Additional game fish collected included walleye, northern pike, rainbow trout and mountain whitefish. Various non-game fish species were sampled in 1985 and in earlier studies (Table 1). Known paddlefish concentration areas (Figure 10) were monitored closely for the presence of paddlefish during the spring of 1985. No paddlefish were observed in the study area in 1985. Early spring flows approached normal levels through early May (Figure 11), peaked briefly at 11,000 cfs, fluctuated, and then rapidly declined during late May and June to extreme low flow conditions in July. Berg (1981) found that paddlefish require a flow of 14,000 cfs in the Virgelle gaged reach of the Missouri to initiate a spring migration to spawning sites. Paddlefish probably did not ascend the river above Fred Robinson Bridge in 1985 as a result of low flow conditions.

Electroshocking data for shovelnose sturgeon and sauger was divided into spawning and post spawn periods for analysis. Designation of spawning intervals for both species was based on determinations made by Berg (1981). The spawning interval for sauger was considered to be from mid-April through late May and late May through early July for shovelnose sturgeon.

Sauger were three times more abundant in shocking runs conducted during their spawning interval than during postspawn runs (Table 2). Mean length and weight for sauger captured during their spawning interval were both higher than postspawn fish, however, differences were not significant ($p \geq 0.05$). Overall, CPUE for sauger in 1985 (3.7) was nearly identical to the CPUE of 3.6 that Berg (1981) observed in 1976-1979 collections. Rising water level and temperature, in very early spring may have approached normal conditions resulting in a normal distribution of sauger in the middle Missouri River. Sauger were evenly distributed throughout the 1985 study area with one exception. Large numbers of sauger were collected along the steep cliffs just downstream of Virgelle Ferry in April and May.

Shovelnose sturgeon collected during their presumed spawning interval, were both significantly ($p < 0.05$) longer and heavier than postspawn fish (Table 2). While larger fish were collected from late May through early July, their abundance was only one fourth of that observed after their spawning interval. A possible explanation is that a portion of the shovelnose sturgeon moved into the Marias River. The lower Marias River is believed to be an important spawning area for shovelnose sturgeon in the middle Missouri River system (Gardner and Berg 1982).

Postspawn catch rates for shovelnose sturgeon in 1985 were considerably higher than during the spawning interval. This may indicate that these fish were concentrating in key foraging locations, or were fish that had moved back into the Missouri after spawning in the Marias River. Locations within the study area where shovelnose sturgeon were consistently collected, were identified (Figure 12). These locations had similar characteristics; with water depth ranging from 2-5 feet, current velocities in excess of 2.5 ft/s, and an abundance of silt-free cobble and gravel substrate. These locations were all

Table 1. Common and scientific names of fishes collected from the middle Missouri River near Coal Banks landing in earlier studies (Berg 1981) and in 1985.

Common Name	Scientific Name
Bigmouth buffalo	*Ictiobus cyprinellus*
Blue sucker	*Cycleptus elongatus*
Burbot	*Lota lota*
Carp	*Cyprious carpio*
Channel catfish	*Ictalurus punctatus*
Emerald shiner	*Notropis atherinoides*
Fathead minnow	*Pimephales promelas*
Flathead chub	*Hybopsis gracilis*
Freshwater drum	*Aplodinotus grunniens*
Goldeye	*Hiodon alosoides*
Lake chub	*Couesius plumbeus*
Longnose dace	*Rhinichthys cataractae*
Longnose sucker	*Catostomus catostomus*
Mottled sculpin	*Cottus bairdi*
Mountain sucker	*Catostomus platyrhynchus*
Mountain whitefish	*Prosopium williamsoni*
Northern pike	*Esox lucius*
Paddlefish	*Polydon spathula*
Pallid sturgeon	*Scaphirhynchus albus*
Rainbow trout	*Salmo gairdneri*
River carpsucker	*Carpoides carpio*
Sauger	*Stizostedion canadense*
Shorthead redhorse	*Moxostoma macrolepidotum*
Shovelnose sturgeon	*Scaphirhynchus platorynchus*
Smallmouth bass	*Micropterus dolomieui*
Smallmouth buffalo	*Ictiobus bubalus*
Stonecat	*Noturus flavus*
Walleye	*Stizostedion vitreum*
Western silvery minnow	*Hybognathus argyritis*
White crappie	*Pomoxis annularis*
White sucker	*Catostomus commersoni*
Yellow perch	*Perca flavescens*

Table 2. Catch statistics for sauger and shovelnose sturgeon collected by electroshocking the middle Missouri River from Six Mile Coulee to Alkali Creek from mid April through early August 1985.

	Shovelnose Sturgeon			Sauger		
Parameter	Spawning	Postspawn	Overall	Spawning	Postspawn	Overall
Mean Weight (g)	3485	2988	3170	293	263	283
Mean Length (mm)	914	864	882	336	314	329
Total Number	62	106	168	81	36	117
Units Effort (hr)	14.5	6.5	21.0	13.5	18.0	31.5
CPUE	4.3	16.3	8.0	6.0	2.0	3.7

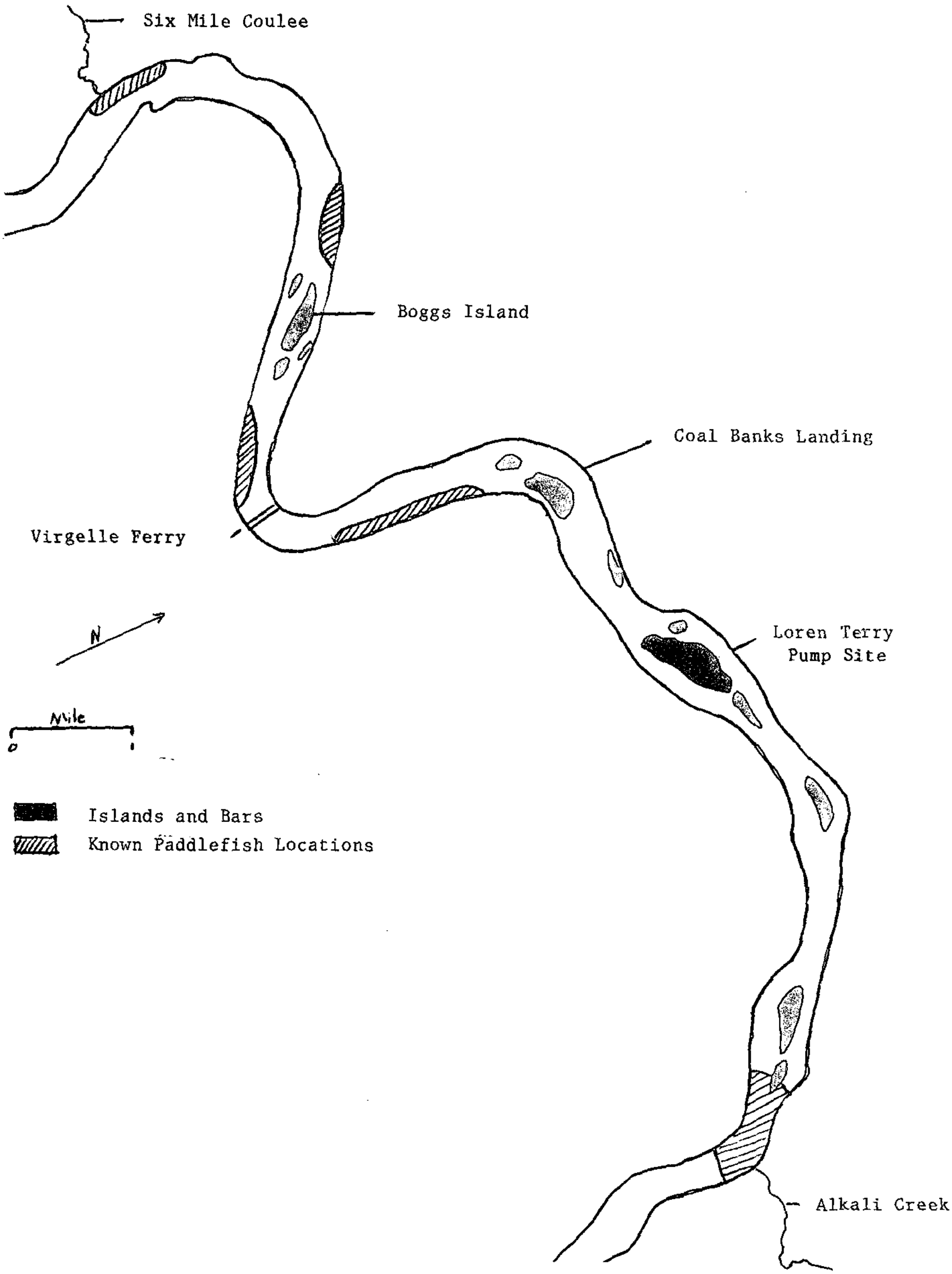


Figure 10. Areas identified as important paddlefish staging locations during spring migrations in the middle Missouri River. Data from Berg (1981) and Gardner and Berg (1982).

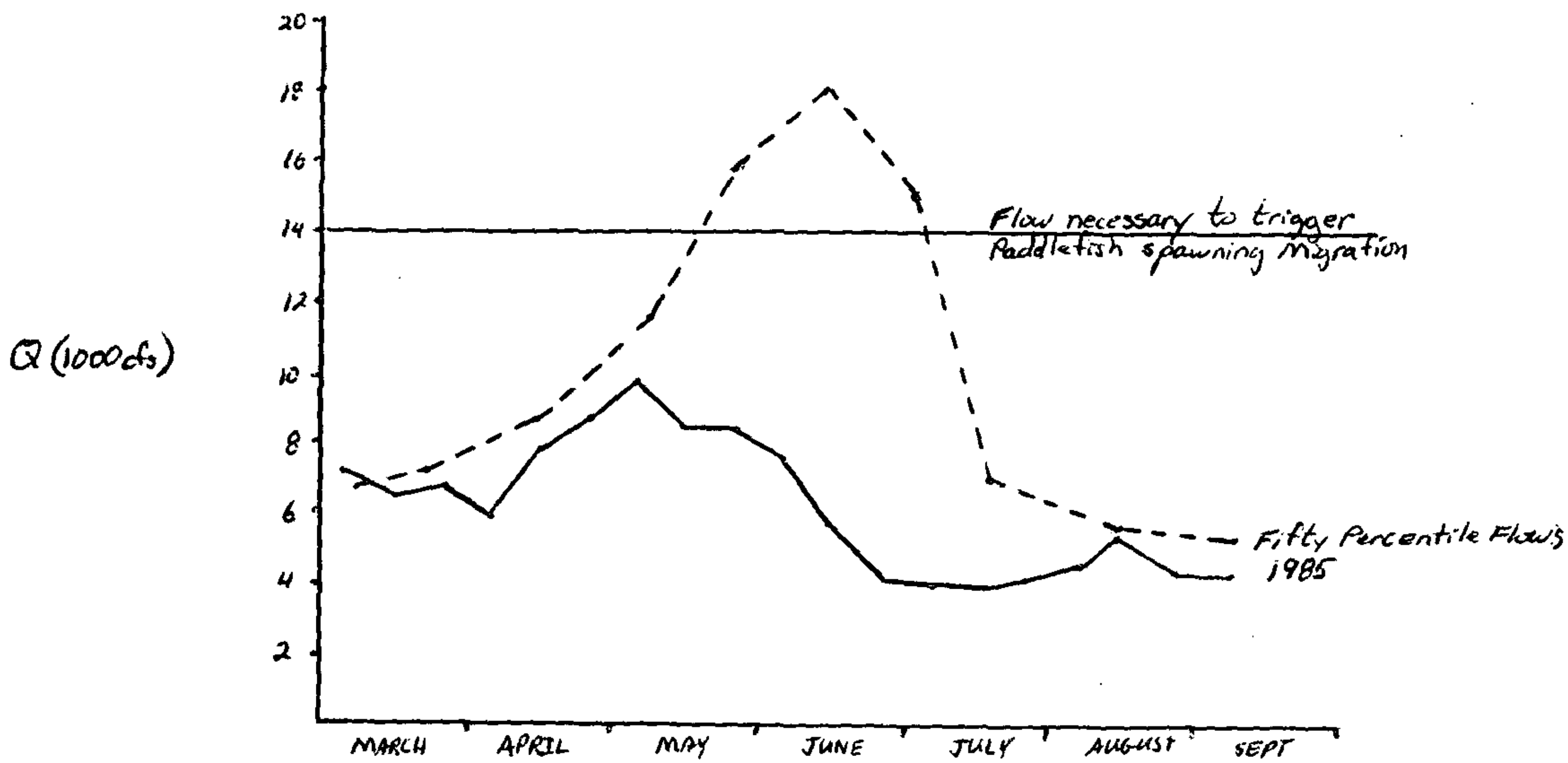


Figure 11. Ten-day average flows for the Virgelle gaged reach of the middle Missouri River, calculated from USGS provisional flow records, 1985, and fifty percentile flows for the Virgelle gage from 1936-1979.

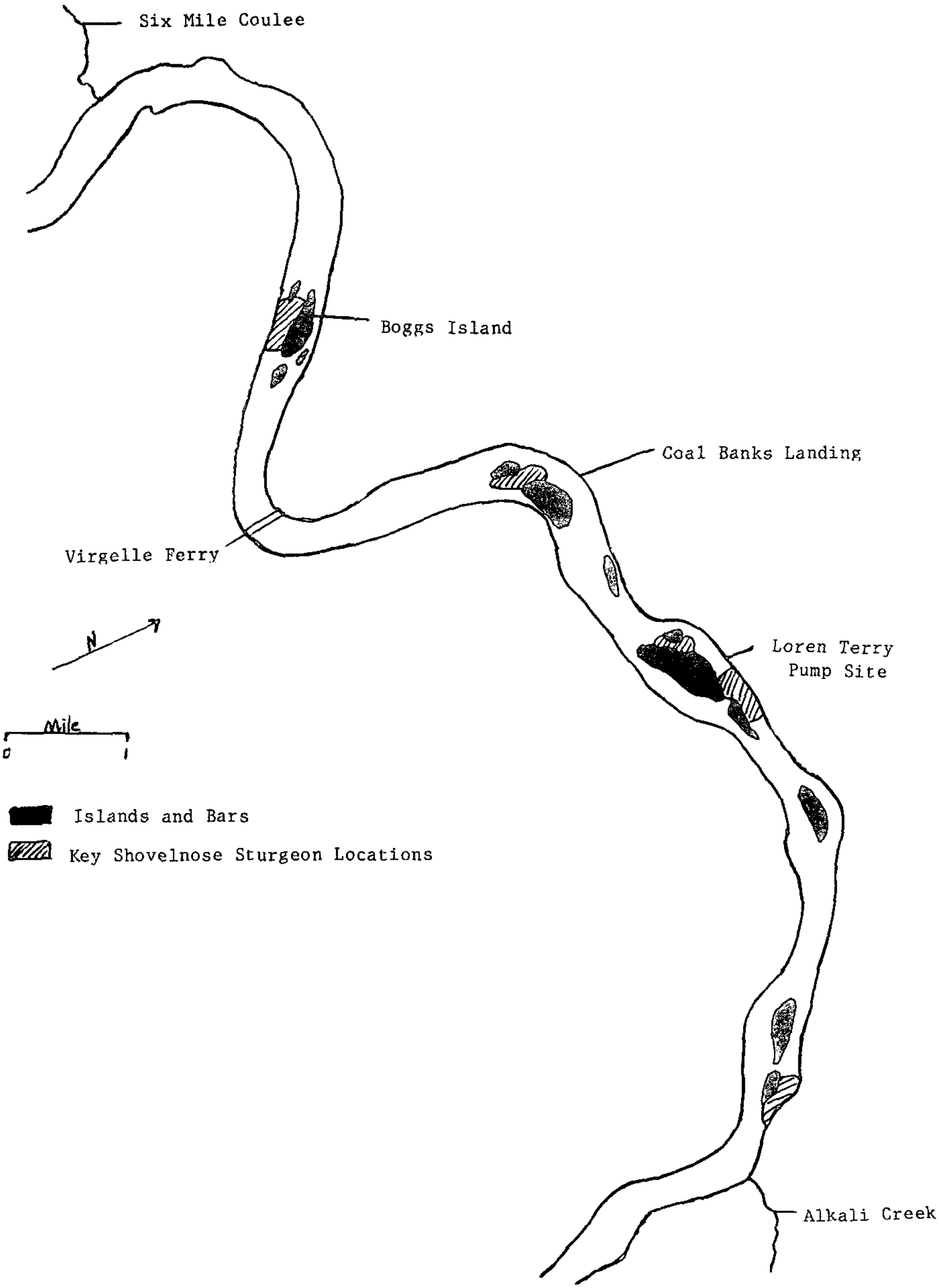


Figure 12. Locations where shovelnose sturgeon were consistently collected during electrofishing surveys on the middle Missouri River, 1985.

associated with channel narrowing and permanent island development. On 8 August a very large concentration of shovelnose sturgeon was found adjacent to Boggs Island. A CPUE of 24.7 was recorded on this date for the entire study area.

Larval Fish

A total of 5,014 larvae were collected in 304 samples taken from the middle Missouri River in 1985. Eight genera representing three families were collected. Taxonomic similarities made distinguishing between white and longnose suckers (Catostomas spp.) and shorthead redhorse (Moxostoma sp.) difficult. For this reason these genera were combined for analysis. For similar reasons bigmouth and smallmouth buffalo (Ictiobus spp.) and river carpsucker (Carpoides sp.) were combined. Additional genera collected included goldeye (Hiodon sp.), carp (Cyprinus sp.), emerald shiner (Notropis sp.) and western silvery minnow (Hybognathus sp.).

The Catostomas/Moxostoma group accounted for 94.1 percent of the total larval fish collected (Table 3). The Ictiobus/Carpoides group accounted for an additional 4.9 percent. Combined, all catostomid genera comprised 99 percent of the total number of fish larvae collected. A total of 2,704 fish eggs were collected in drift net samples. Goldeye (83.7 percent) and catostomid (16.3 percent) eggs were the only taxa represented.

Recent larval fish studies on the middle Missouri River by Berg (1981), and Gardner and Berg (1982), documented a similar dominance of catostomid larvae in drift net samples. Additional taxa collected in these studies included sauger, shovelnose sturgeon, paddlefish, mountain whitefish, stonecat and sculpins. The current study was far more intensive than these earlier studies however, representatives of the aforementioned species were not collected.

Spatial Distribution

The mean density of larval fish collected from the Six Mile Coulee survey site (25.1 larvae/100m^3) was the highest collected throughout the study area (Table 4). Densities found at the Coal Banks Landing and the Upper Pump survey sites (18.0 and 17.6/100m^3 respectively) were quite similar. The lowest density of larval fish was found at the Lower Pump survey site. Current velocities of the Lower Pump site were quite swift, in excess of 4 ft/s. Based on current velocity orientation findings it is believed that fish larvae may have oriented themselves closer to the banks along this reach of river and not have been represented proportionally in mid-river survey samples. While larval fish densities varied among survey sites, analysis of variance indicated differences were insignificant ($p \geq 0.05$) for all taxa. Taxonomic composition of fish larvae was similar among survey sites.

Researching the middle Missouri River in 1978 Berg (1981) collected larval fish samples from Carter Ferry to Fred Robinson Bridge. The highest density of fish larvae collected occurred at the Coal Banks Landing Site (306.8/100m^3). The mean density for all samples throughout the middle Missouri River in Berg's study was 54.8/100m^3. This compares to a mean density of 15.6/100m^3 for all survey site samples in 1985. Flow regimes in 1978 for the middle Missouri River during the spring/summer spawning, incubation, drift and rearing intervals were considered normal. Flow regimes in 1985 were considerably less than normal throughout the spring and summer, most likely resulting in reduced spawning

Table 3. Taxonomic composition and total numbers of fish larvae sampled in the middle Missouri River near Coal Banks Landing from early May to late August, 1985.

LARVAE			EGGS		
Taxa	Number	Percent	Taxa	Number	Percent
Catostomas / *Moxostoma*	4717	94.08	*Hiodon alosoides*	2263	83.69
Carpoides / *Ictiobus*	246	4.91	Catostomid	441	16.31
Hiodon alosoides	22	0.41			
Cyprinus carpio	24	0.48			
Notropis atherinoides	3	0.06			
Hybognathus nuchalis	2	0.02			
Total	5014			2704	

Table 4. Taxonomic composition and mean densities (Number/100m³) of fish larvae and eggs sampled from six survey sites on the middle Missouri River from early May through late August, 1985.

Taxa	Survey Site					
Larvae	*Six Mile* Coulee	*Coal Banks* Landing	*Bypass* Channel	Upper Pump	Lower Pump	Alkali Creek
Catostomus / Moxostoma	24.0	16.8	11.8	17.2	7.6	10.0
Carpoides / Ictiobes	0.9	1.0	0.7	0.4	1.4	1.2
Hiodon alosoides	0.1	0.1	tr. 1/	tr. 1/	0.1	tr. 1/
Cyprinus carpio	0.1	0.1	0.2	tr. 1/	0.1	0.1
Notropis atherinoides	0	0	0	0	tr. 1/	0
Hybograthus nuchalis	0	0	tr. 1/	0	tr. 1/	0
Total	25.1	18.0	12.7	17.6	9.2	11.3
Eggs						
Hiodon alosoides	10.6	9.6	5.7	8.0	7.7	5.0
Catostomid	2.9	1.1	0.7	0.8	1.1	3.5
Total	13.5	10.7	6.4	8.8	8.8	8.5

1/ tr. denotes a mean density of less than 0.1 larvae/100m³.

success of some species and a complete failure by others. Poor overall spawning success would result in subsequent low larval fish density and species diversity.

Temporal Abundance

Rising water temperatures and increased spring flows have been determined to be the releasing stimuli necessary to trigger spawning activity for many warm water species in riverine environments (Hynes 1970). The eggs and larvae of most fish are present for only a short period of time each year, depending on their specific spawning seasons, incubation periods, and rates of larval growth and development in waters of concern (Snyder 1983). Variables governing the temporal abundance of fish eggs and larvae are quite complex. In the present study fluctuations in water temperature and flow levels appear to be factors that affected larval fish abundance in samples collected from the middle Missouri River in 1985 (Figures 13 and 14). Floyd et al. (1984) researching a warm water stream in Kentucky documented similar fluctuations in temporal abundance and suggested variations in water temperature and flow were the factors responsible.

Findings in earlier work done on the Missouri River (Berg 1981; Gardner and Berg 1982) suggest the occurrence of multiple peaks in temporal larval fish abundance were related to changes in species composition, with catostominae predominating the catch in early samples succeeded by ictiobinae and cyprinidae in the later collections. Similar, however less obvious, trends were observed in the current study (Table 5).

An attempt was made to identify the time interval for each taxa when their occurrence in the drift was significant. Fluctuations in abundance of Catostomas/Moxostoma larvae make the identification of a specific drift interval difficult. From early May through early July Catostomas/Moxostoma were abundant in drift samples (Figure 15). Cyprinid larvae were collected from mid-June through late July. Highest densities of Carpoides/Ictiobus larvae were collected from early June through early July. Goldeye eggs were abundant in drift samples from late May through early June and larvae, from early June through late July.

Very few larval fish were collected from the middle of July through late August. These findings suggest that the period from early May through mid-July under the low flow conditions experienced in 1985, was the critical interval for the presence of fish larvae within the study area. As previously mentioned, relatively few of the taxa normally occurring in the drift were collected in 1985 due to low flow conditions. The interval for drifting larvae for the species collected in 1985 may not be representative for species absent from the 1985 samples, or for all species under more normal flow conditions.

Horizontal and Vertical Distribution

No statistically significant ($p \geq 0.05$) differences in mean larval fish densities were detected in horizontal intense samples, however, several important trends were evident. Larval fish density was the greatest along the left bank for both the Catostomas/Moxostoma group and the Carpoides/Ictiobus group. Cyprinids, while collected in low numbers, were most abundant along the right bank. Researching a warmwater stream in Pennsylvania Gerlach and Kahnle

Table 5. Temporal abundance of fish larvae and eggs collected from the six survey sites in the middle Missouri River. Numbers represent mean densities (Number/100m^3) for samples collected from 9 May through 23 August, 1985.

	LARVAE				EGGS
DATE	*Catostomus/ Moxostoma*	*Carpoides/ Ictiobus*	*Hidon alosoides*	Cyprinid	*Hiodon alosoides*
5/9	18.8	0.0	0.0	0.0	0.0
5/15	4.1	0.0	0.0	0.0	0.0
5/22	0.6	0.0	0.0	0.0	0.5
5/29	22.2	0.6	0.0	0.0	53.1
6/6	21.6	1.0	0.1	0.0	23.5
6/12	12.4	2.2	0.1	0.2	0.3
6/19	31.0	1.8	0.2	0.0	0.1
6/27	6.7	1.6	0.3	0.1	0.0
7/2	23.4	2.3	0.0	0.2	0.1
7/11	4.5	0.0	0.0	0.5	0.0
7/16	1.4	0.2	0.0	0.3	0.0
7/25	0.1	0.0	0.0	0.0	0.0
8/8	0.1	0.0	0.0	0.0	0.0
8/23	0.1	0.0	0.0	0.0	0.0

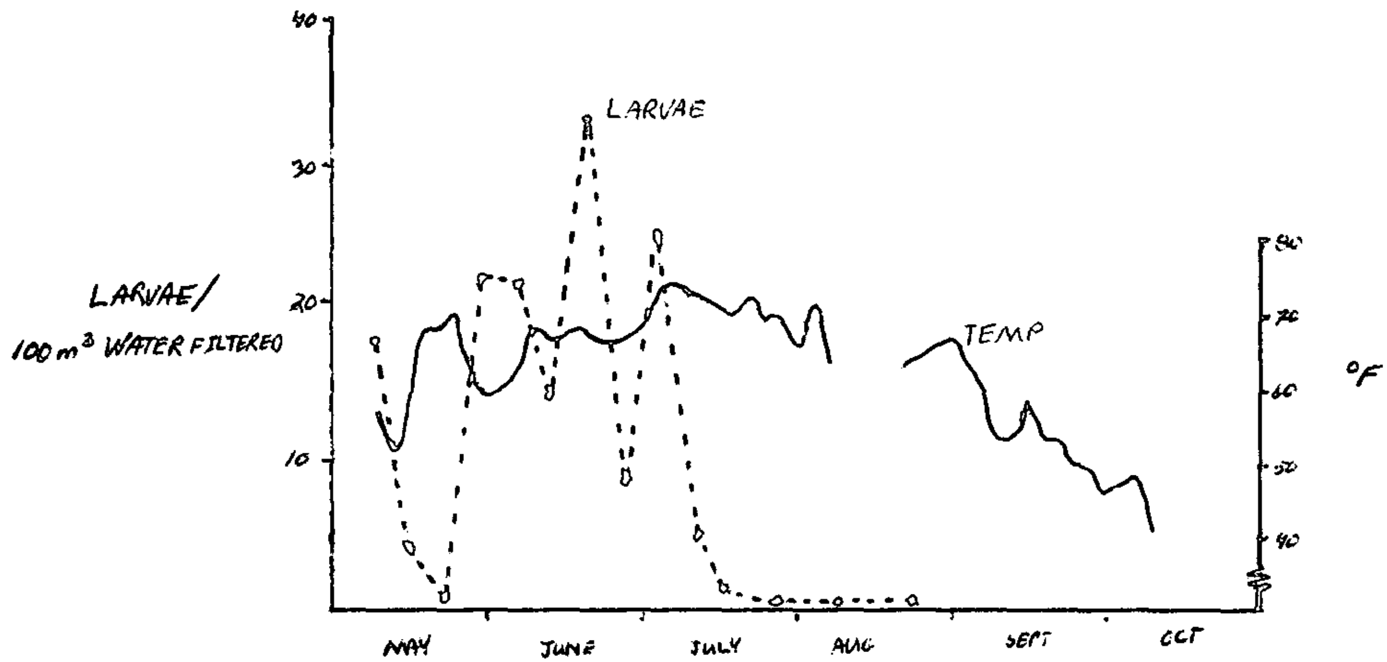


Figure 13. Temporal abundance of fish larvae sampled from six survey sites on the middle Missouri River from early May to late August, and daily high water temperatures recorded at Virgelle Ferry from early May to mid-October, 1985.

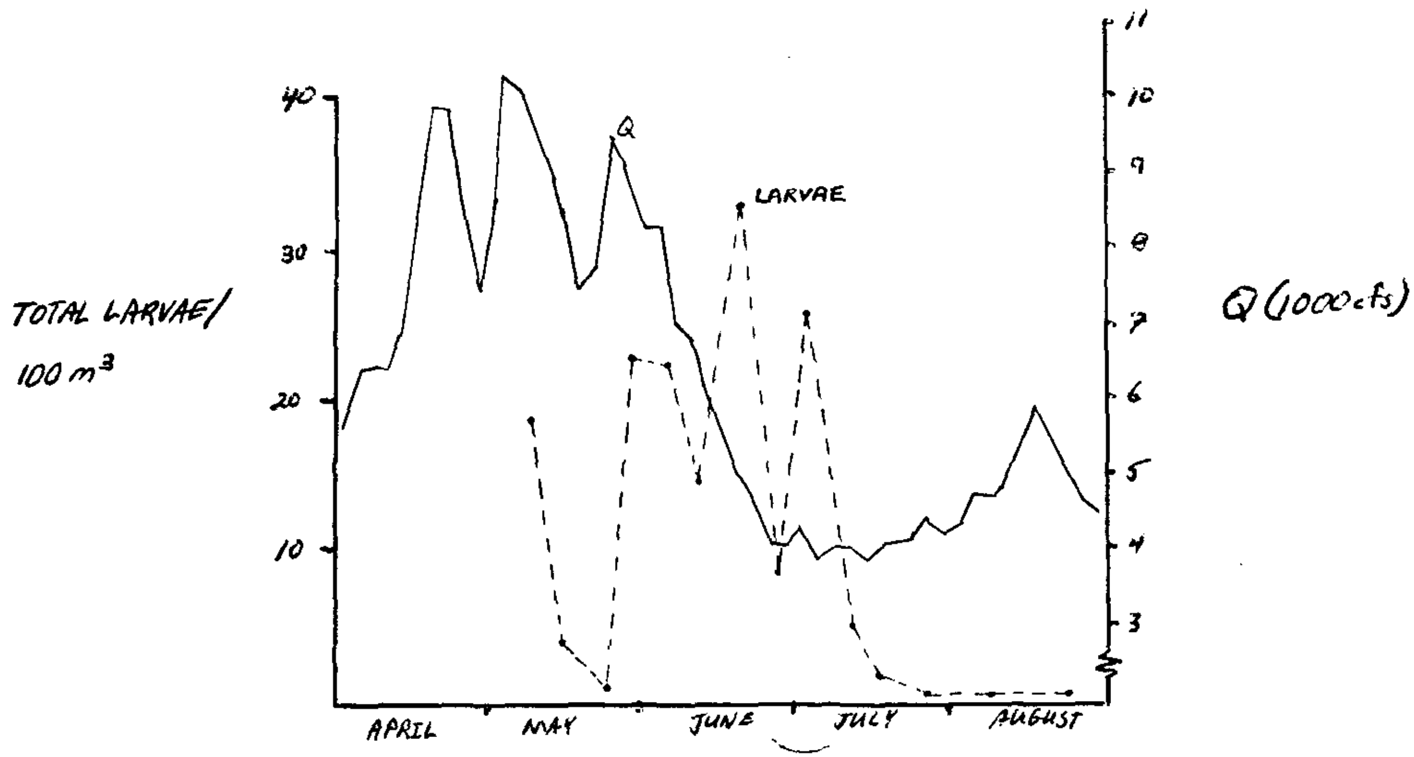


Figure 14. Temporal abundance of fish larvae sampled from six survey sites on the middle Missouri River from early May to late August, and three-day average flows for the Virgelle gaged reach of the Missouri River, derived from USGS provisional flow records, 1985.

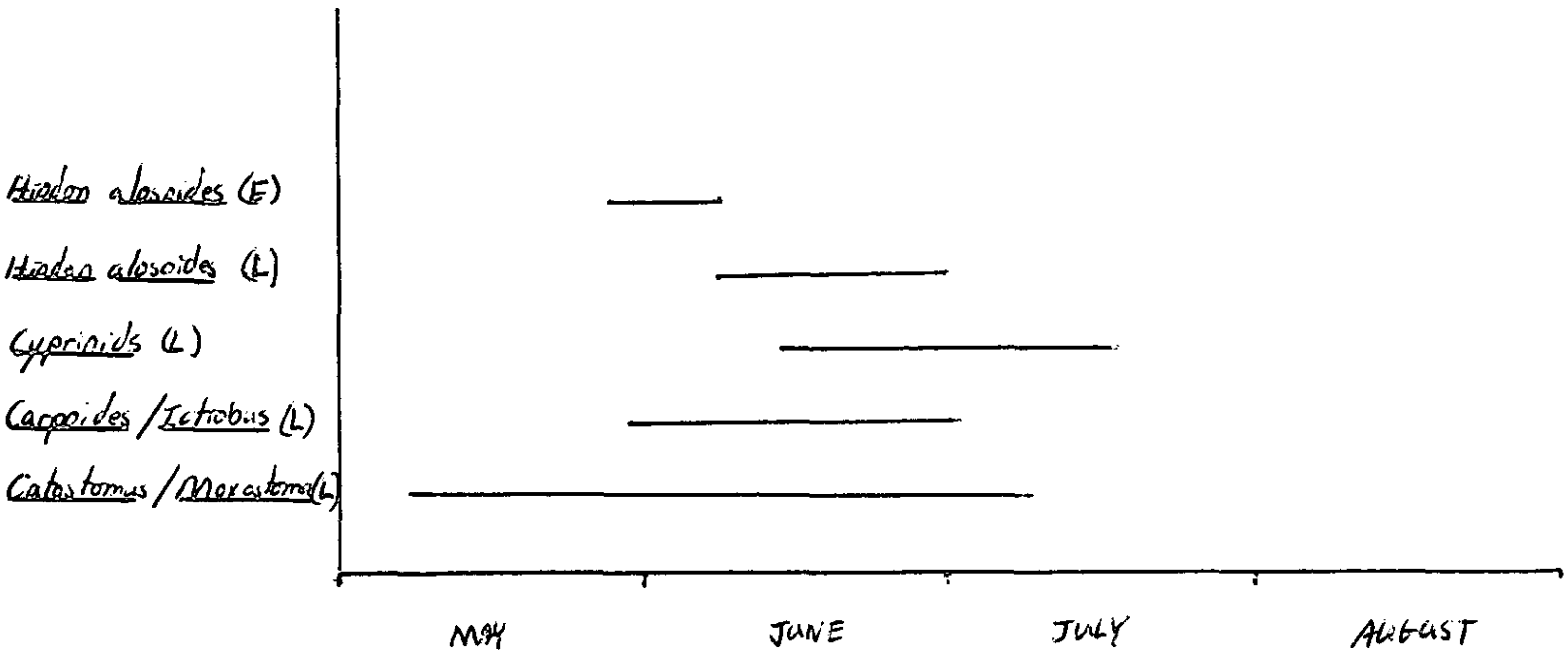


Figure 15. Intervals for fish larvae (L) and eggs (E) occurring in drift net samples from the middle Missouri River, near Coal Banks Landing, 1985.

(1981) documented similar horizontal variations in larval fish abundance. They suggested that horizontal gradients in drift appeared to be related to location of spawning and nursery areas.

Significantly ($p < 0.05$) greater numbers of Catostomas/Moxostoma larvae were collected in surface samples (Table 6). Mean Carpoides/Ictiobus density was higher in mid-depth samples, however differences were not statistically significant ($p \geq 0.05$). The density of goldeye larvae was similar for the three various depths however, goldeye egg density increased with depth. Total larval fish density was significantly ($p < 0.05$) higher in surface samples than from those collected at mid-depth and off the bottom.

Current Velocity Orientation

Current velocity profiles were determined at low and medium flows adjacent to the Loren Terry Pump Site (Figure 16). Larval fish drift data was correlated to current vectors based on drift net orientation in the channel and checked against current velocities obtained from meters during larval fish sampling. In general, as flow increased in the river a corresponding depression in the velocity contours was observed. A maximum velocity of 2.54 ft/s was recorded at a flow of 4402 cfs. At 8804 cfs a considerable portion of the river cross section had current velocities exceeding 2.5 ft/s with a maximum velocity of 3.57 ft/s. The left bank of the channel was slightly steeper with velocity contour bands somewhat narrower.

Larvae of the Catostomas/Moxostoma group were present in drift samples where velocities ranged from 1.0-2.5 ft/s. At flows in excess of 2.5 ft/s there was a reduction in abundance. A similar reduction in abundance was observed when velocities were less than 1.0 ft/s. At velocities less than 1.0 ft/s, sampling efficiency may have been reduced due to gear avoidance (Snyder 1983). Highest numbers of Carpoides/Ictiobus were collected at velocities less than 2.0 ft/s. It appeared that Carpoides/Ictiobus were somewhat less tolerant of higher velocities than the Catostomas/Moxostoma group. Cyprinid larvae were collected where velocities were less than 1.0 ft/s. Brown (1971) indicates that cyprinids have a preference for slower waters than catostomids. Larval goldeye were oriented to velocities less than 1.5 ft/s. Goldeye, like cyprinids, have a preference for calm waters for spawning and incubation (Scott and Crossman 1973).

Goldeye eggs are semi-buoyant and are suspended in the water column by turbulence (Balon 1975). Goldeye eggs were collected in mid-river samples and abundance increased with depth. Most cyprinids and catostomids are open substrate spawners and have eggs that are demersal and adhesive, and are rarely found in the water column (Marcy et al. 1980). Catostomid eggs collected in the current study were most often associated with drifting filamentous algae, closer to the bottom.

Diel Periodicity

Vision is considered to be the most important sense during the larval period hence light appears to be an extremely influential stimulus during this period (Marcy et al. 1980). Diel changes in light intensity often govern the activity levels of fish (Emery 1973). In the current study diurnal fluctuations in larval fish abundance were documented (Table 7). Total larval fish density was

Table 6. Horizontal and vertical distribution of fish larvae and eggs at the Loren Terry Pump Site. Numbers represent mean densities (Number/100m^3) for samples collected from 10 May through 12 July, 1985.

	LARVAE					EGGS	
HORIZONTAL	Catostomus/ Moxostoma	Carpoides/ Ictiobus	Hiodon alosoides	Cyprinid	Total Larvae	Hiodon alosoides	Catostomid
LEFT BANK	19.3	0.3	0.0	0.0	19.6	1.3	0.3
MID-RIVER	11.6	0.1	tr.	0.1	11.8	3.4	0.6
RIGHT BANK	11.9	0.1	0.0	0.2	12.2	2.7	0.6
VERTICAL							
SURFACE	14.4	0.2	0.1	0.1	14.8	3.4	1.7
MID-DEPTH	2.6	0.4	0.1	tr.	3.1	4.4	1.3
BOTTOM	1.8	0.2	0.1	0.0	2.1	7.3	3.4

1/ tr. denotes a mean density of less than 0.1 larvae/100m^3.

Table 7. Diel fluctuations in abundance of fish larvae present in drift samples from the middle Missouri River at the Loren Terry Pump Site. Numbers represent mean density (Number/100m^3) for samples collected on 11 June, 1985.

	TAXA			
TIME PERIOD	Catostomas/ Moxostoma	Carpoides/ Ictiobus	Hiodon alosoides	Total Larvae
NOON	15.4	0.0	0.0	15.4
DUSK	19.4	0.6	0.0	20.0
MIDNIGHT	31.6	2.0	0.5	34.1
DAWN	38.2	0.6	0.0	38.8

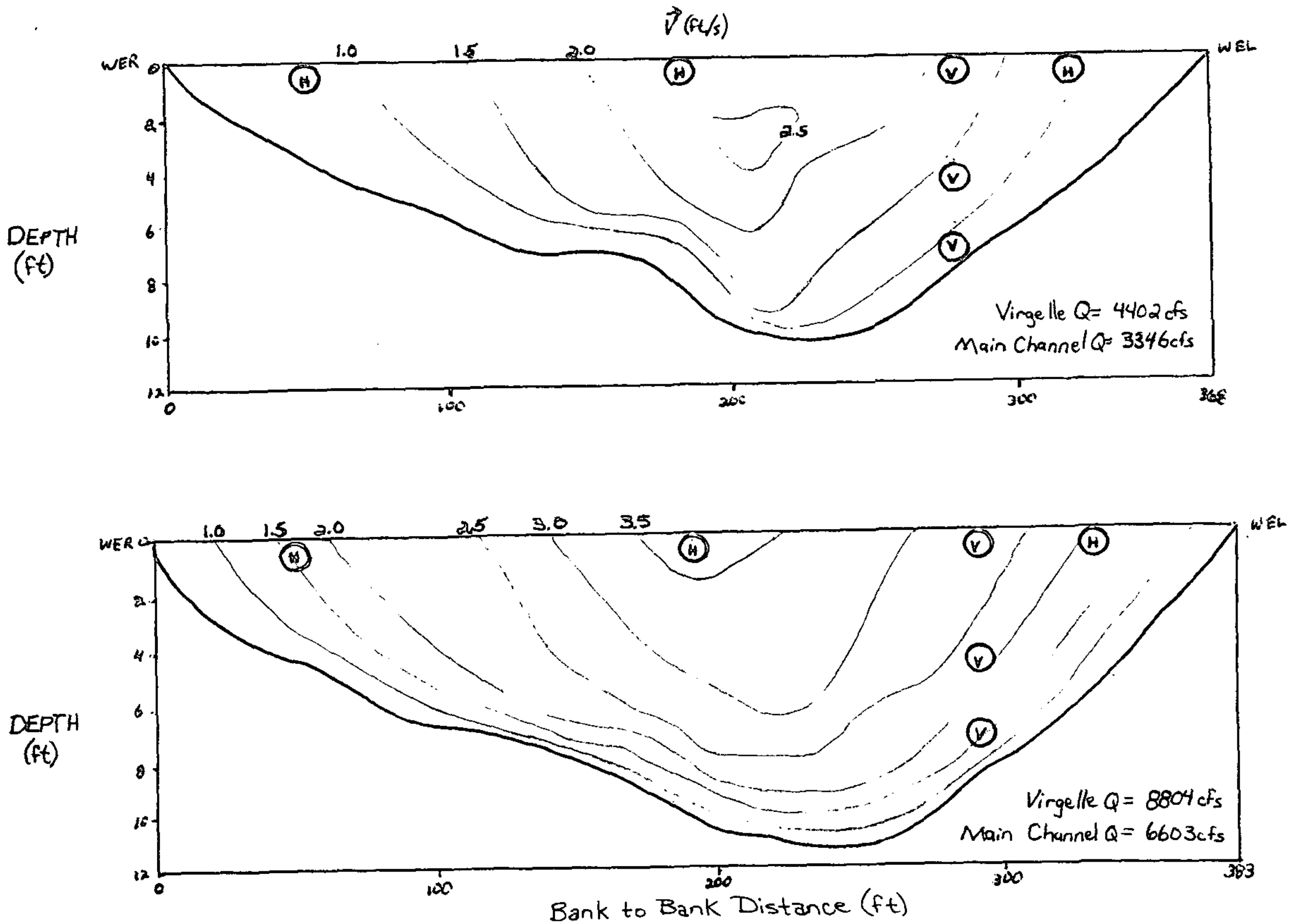


Figure 16. Current velocity profiles and drift net orientation, looking upstream, for horizontal (H) and vertical (V) intense larval fish samples collected at the Loren Terry Pump Site at low and moderate flow regimes, 1985.

highest during the dawn sampling period and lowest during the noon period. These differences were not significant ($p \geq 0.05$), more likely due to the small number of samples collected, than to actual diel variation in larval drift intensity. Gale and Mohr (1978) researching a large river in Pennsylvania found 3.8 times more larvae in samples collected at night than during the daylight hours, with peak densities occurring between midnight and three in the morning. Other researchers (Gerlach and Kahnle 1981; Tarplee and Partin 1981) have documented similar diel fluctuations in larval fish drift. In their work on the Schuylkill River in Pennsylvania Gerlach and Kahnle (1981) found numbers of larvae were greatest at night and usually peaked near 2200 hours, with an average day/night drift ratio of 1:9. They found that larvae tended to drift near the bottom during the day and near the surface at night. In the current study nearly twice as many larvae were collected in midnight-dawn samples than from noon-dusk samples.

Nocturnal increases in drift of larval white sucker and longnose sucker have been documented in past studies (Clifford 1972; Geen et al. 1966). In the present study Catostomas/Moxostoma larvae were most abundant in samples collected during the midnight and dawn sampling periods. These differences were not statistically significant ($p \geq 0.05$), but again the small number of samples collected may have influenced the analysis. Larval Carpoides/Ictiobus and goldeye were collected in significantly ($p < 0.05$) higher numbers during the midnight time period.

Young-of-the-Year and Forage Fish

From early August through mid-September, 1985, 52 seine hauls were completed in all seinable river habitats. A total of 16,758 fish, representing twelve species were sampled. Four cyprinid and three catostomid species accounted for 96 percent of the fish collected (Table 8). Shorthead redhorse, longnose and white sucker (Catostomus spp.) and river carpsucker were the most common catostomids (CPUE = 83.5, 34.0 and 19.7 respectively). Common cyprinids included emerald shiner, flathead chub, longnose dace and fathead minnow. Catch rates for these cyprinids were 61.8, 49.1, 41.5, and 20.5 respectively. Less frequently seined species included carp, western silvery minnow, lake chub, bigmouth buffalo and channel catfish. In 1979 Gardner and Berg (1982) also seined YOY mountain whitefish, sauger and mottled sculpin near Coal Banks Landing, but did not collect bigmouth buffalo or channel catfish. All species except bigmouth buffalo and channel catfish, were sampled in each of the subreaches and every habitat type.

Considerable variation in CPUE was observed among habitat types (Table 9). Catch rates were the highest from side channel pool habitat, followed by main channel pool, main channel border and side channel chute. No backwater habitat was identified within the 1985 study area. Shorthead redhorse, fathead minnow and emerald shiners were most common in pool habitats, while longnose dace were equally distributed in all four habitat types (Figure 17).

These results differ from studies conducted in 1979 (Gardner and Berg 1982). Average CPUE and species diversity for each habitat type were much lower in the earlier study (Table 10). Possible reasons for these differences relate to

Table 8. Catch rates and species composition of fishes collected by seining various habitats in the middle Missouri River during August and September, 1985. Catch rates (CPUE) represent mean number of fish collected per seine haul.

Species	Habitat Type				Summary	
	MAIN CHANNEL BORDER CPUE	MAIN CHANNEL POOL CPUE	SIDE CHANNEL CHUTE CPUE	SIDE CHANNEL POOL CPUE	OVERALL CPUE	PERCENT OF Total No.
Shorthead redhorse	41.4	185.5	7.7	179.5	83.5	25.9
Emerald Shiner	61.6	85.5	3.1	122.3	61.8	19.2
Flathead chub	34.0	26.7	46.1	157.5	49.1	15.2
Longnose dace	40.9	36.6	37.7	60.3	41.5	12.9
Catostomas spp.	32.0	11.8	13.4	124.2	34.0	10.6
Fathead minnow	12.1	52.0	0.1	27.5	20.5	6.4
River carpsucker	10.3	16.1	20.4	61.8	19.7	6.1
Carp	4.7	3.6	3.0	16.8	5.5	1.7
Western silvery minnow	5.6	1.3	3.4	5.5	4.2	1.3
Lake chub	0.7	0.8	0	16.5	2.4	0.1
Bigmouth buffalo	0	0.2	0.1	0	0.1	0
Channel catfish	0	0.1	0	0	0	0

Table 9. Summary statistics for fishes (all species combined) collected by habitat type and river subreach in the middle Missouri River during August and September, 1985.

Subreach	Main Channel Border		Main Channel Pool		Side Channel Chute		Side Channel Pool		Total	
	Hauls	CPUE	Hauls	CPUE	Hauls	CPUE	Hauls	CPUE	Hauls	CPUE
BOGGS	4	116.2	2	934.5	4	42.5	0	N/A	10	250.7
COAL BANKS	10	406.9	7	380.8	5	162.6	3	766.0	25	393.8
LITTLE SANDY CREEK	9	118.9	3	168.0	2	251.5	3	778.0	17	259.3
TOTAL	23	243.5	12	419.9	11	135.0	6	772.0	52	322.2

Table 10. Comparison of catch statistics for fishes collected by seining on the middle Missouri River in 1979 (Gardner and Berg, 1981) and 1985.

Habitat Type	CPUE			Mean Number of Species/Haul			Number of Hauls		
	1979 1/	1979 2/	1985	1979 1/	1979 2/	1985	1979 1/	1979 2/	1985
Main Channel Border	45.2	120.0	243.5	3.6	3.8	6.0	84	10	23
Main Channel Pool	104.2	119.4	419.9	4.8	4.1	7.8	68	7	12
Side Channel Chute	30.6	20.0	135.0	3.3	4.0	5.1	18	2	11
Side Channel Pool	81.3	27.5	772.0	5.5	3.0	7.2	26	2	6
Backwater	125.2	284.0	N/A	5.8	10.0	N/A	46	1	0
Mean/Total	79.8	109.8	322.2	4.5	4.1	6.3	242	22	52

1/ From Gardner and Berg (1981) - Entire middle Missouri River from Morony Dam to Turkey Joe.

2/ From Gardner and Berg (1981) - Coal Banks study area only. From 3½ miles upstream of 1985 study area to 3 miles downstream from 1985 study area.

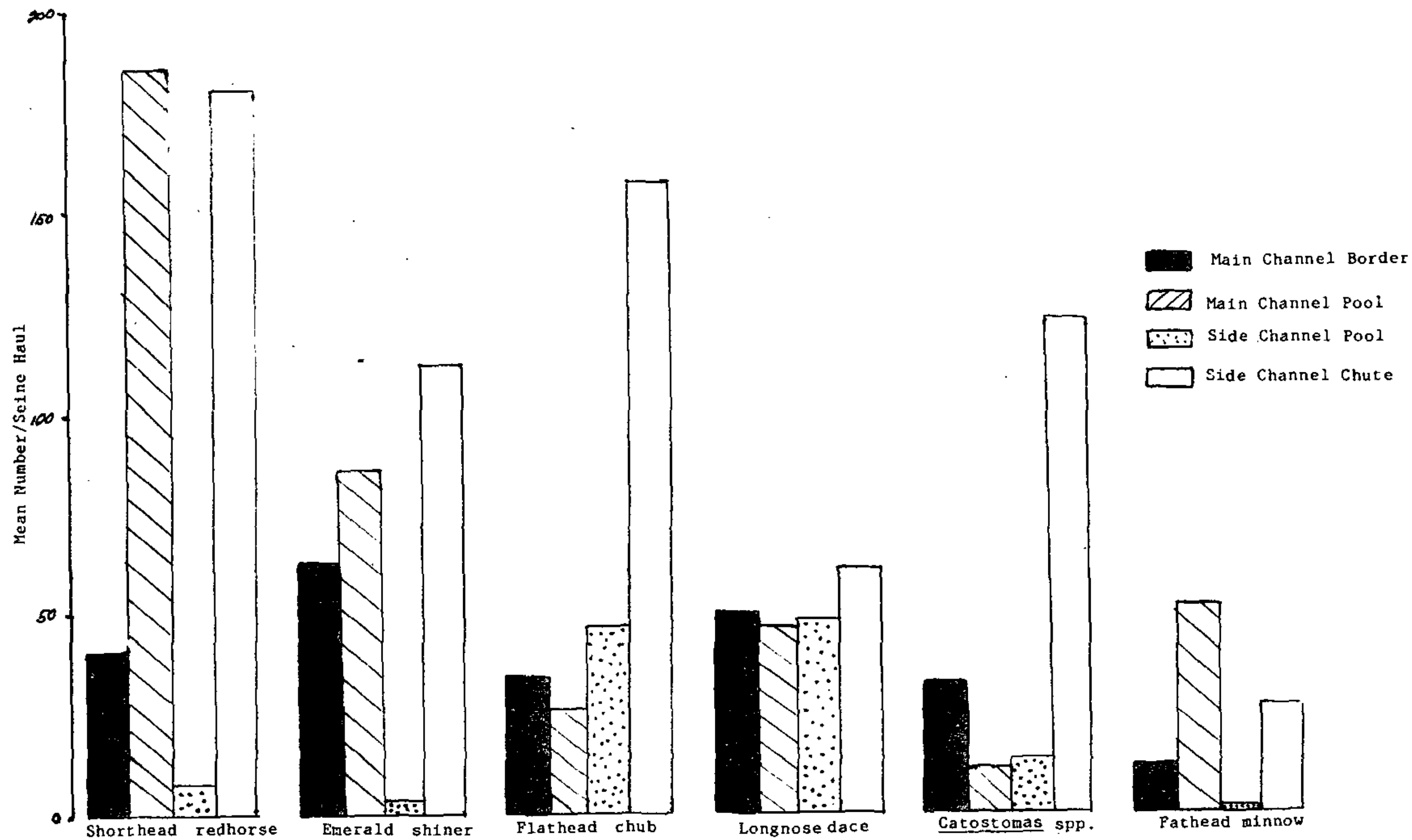


Figure 17. Habitat distribution of the six most common species collected seining on the middle Missouri River in August and September, 1985.

variation in seining intensity, differences in study areas and division of habitat types, and the extremely low flow conditions in 1985. Reduction of potential rearing habitat by low flow conditions may have concentrated fish in available shoreline areas.

Variations in fish distribution and abundance were less pronounced in river subreaches than among habitat types (Figure 18). Catch rates from the Coal Banks subreach were 1.5 times higher than the other two subreaches (Table 9), and five of the common species were most abundant within that section. Average CPUE's for the Boggs and Little Sandy Creek subreaches were quite similar despite the absence of side channel pool habitat in the Boggs subreach. Catch rates from main channel pool habitat in the Boggs subreach were quite high suggesting, in the absence of side channel pools, main channel pools become the primary rearing habitat.

One objective of this study was to identify the project area's nursery habitat value for such species as sauger, shovelnose sturgeon and channel catfish. Sauger and shovelnose sturgeon were not sampled in seining efforts, while only one YOY channel catfish was collected. The absence of these species in the seining samples does not necessarily indicate the absence of suitable habitat. The unusually low and brief peak flows experienced in 1985 may have significantly reduced the spawning success of these species. These species were also absent from the larval fish samples.

Results of sauger rearing habitat preference studies conducted in 1979 (Gardner and Berg 1982) indicated YOY sauger selected protected habitats in peripheral areas of the Missouri River. Specifically, side channel pools were identified as being the preferred habitat of YOY sauger. This preference for shallow water habitat has been observed by other researchers (Kallemeyn and Novotony 1977; Kozel 1974). Results of survey sampling in 1979 (Gardner and Berg 1982) indicated that most YOY sauger reared in a 47 km reach of the Missouri River from Sturgeon Island to Robinson Bridge. Very few YOY sauger were collected from the Coal Banks Landing area in the previous study. The absence of backwater habitat within the 1985 study area appears to preclude its use as a rearing area for YOY sauger.

Channel catfish are an important and common game fish in the Missouri River (Berg 1981). They are most abundant in river sections with a diversity of current velocities and structural features (McMahon and Terrel 1982). Debris, logs, cavities, boulders, and cutbanks in low velocity (< 15 cm/sec) areas of deep pools and backwaters of rivers will provide cover for channel catfish (Bailey and Harrison 1948). In earlier work done on the middle Missouri River (Gardner and Berg 1982), YOY channel catfish were collected from Cow Island to Robinson Bridge and from the Teton River. Optimal rearing habitat for YOY channel catfish does not appear to be abundant within the 1985 study area. Lower gradient reaches downstream from Cow Island appear to provide the most favorable rearing habitat for YOY channel catfish.

Despite the presence of a large adult population, YOY shovelnose sturgeon have not been collected in the middle Missouri River (Gardner, personal communication). Similar frustrations have been voiced by other Missouri River shovelnose sturgeon researchers (Modde, personal communication). Very little information is available describing optimum habitat for YOY shovelnose sturgeon. Researchers in Iowa have consistantly collected YOY shovelnose sturgeon from

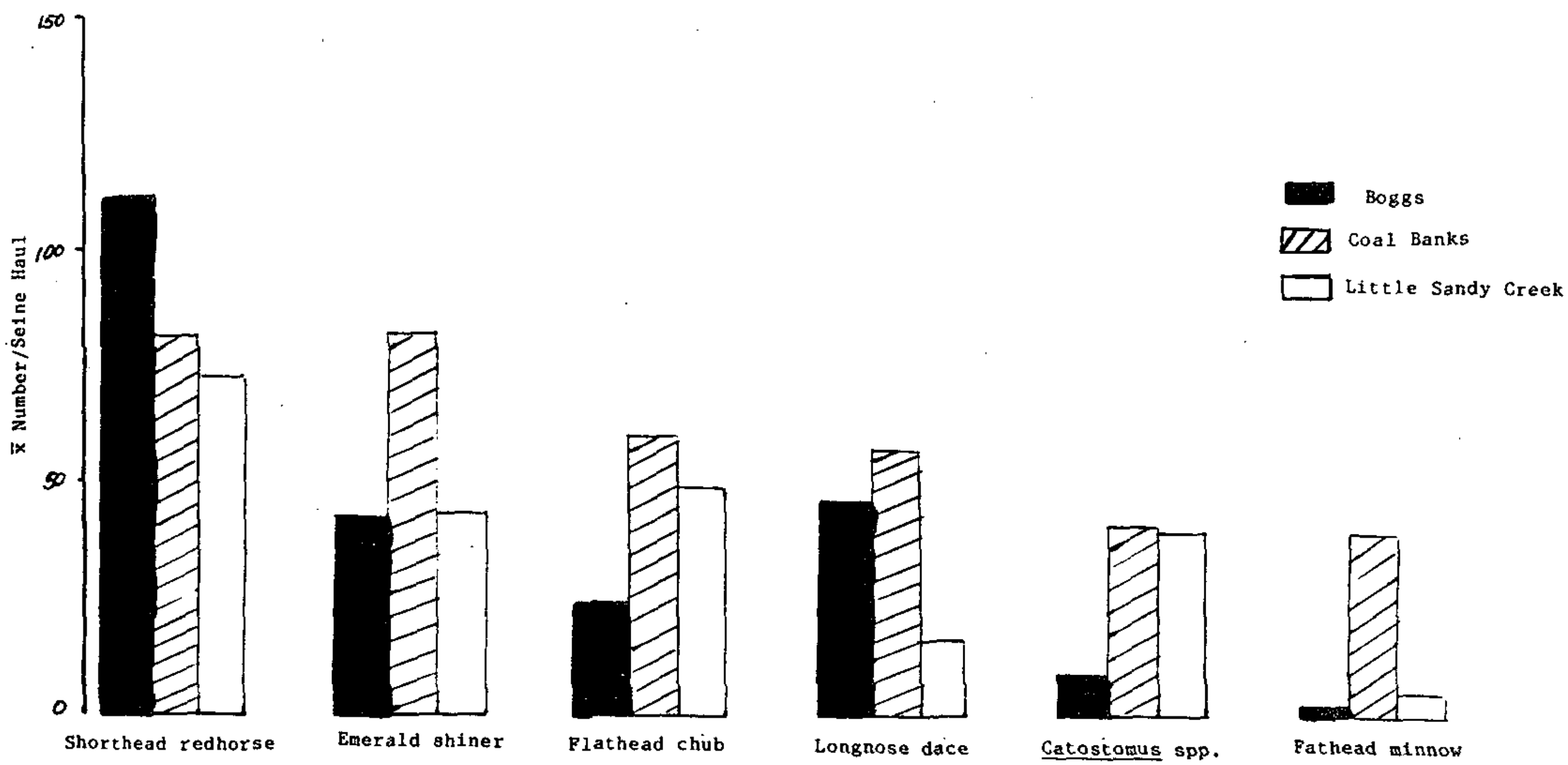


Figure 18. Longitudinal distribution of the six most common species collected seining on the middle Missouri River in August and September, 1985.

Pool 13 on the Mississippi River (Helms, personal communication). These fish were collected by drifting small mesh gill nets through eddies created by wing-dam structures. The location of shovelnose sturgeon rearing areas in the middle Missouri River remains unknown.

River Hydraulics and Dimensions

Staff gage and flow data were used to develop a relationship between the flow at Virgelle and the quantity of water in the main channel at the Loren Terry Pump Site. Water bypassing the main channel was expressed as a percentage of the entire Virgelle gaged flow. A fairly constant relationship was observed with approximately 25 percent of the flow bypassing the main channel. The bypass channel is a permanent side channel, retaining its integrity even during extreme low flow years.

Cross sectional profiles and stage height data generated from the WETP program were graphed for each of the three main channel cross sections and the bypass channel cross section (Figures 19-22). The bypass channel cross section was selected in order to determine potential use by recreationists. The width-at-given-depth and maximum continuous width-at-depth options were used to relate channel dimensions to recreational use. Minimum depth and width criteria have been developed for various types of boating craft by the Cooperative Instream Flow Service Group of the U.S. Fish and Wildlife Service (Hyra, 1978). Floaters (canoes and tubes) would find adequate water in the side channel at Virgelle flows in excess of 1500 cfs. Power boats require greater stream depth and width for operation. Only when flows are in excess of 7000 cfs at the Virgelle gage would power boats be able to safely navigate the side channel.

The chosen intake design when this study was initiated was a submerged intake using Johnson screens. The preferred location was the Loren Terry Pump Site. The exact dimensions of the intake structure were not available, however personal communication with Bureau planning personnel indicated that at least six foot of water depth would be required to operate this particular intake structure. This depth would provide 18 inches of clearance above the screens. An 18 inch clearance would not be sufficient for some power boats to safely operate so we will assume that at least seven feet of water would be necessary to insure safe operation of all watercraft.

Wetted-perimeter cross section 2 in the main channel was located adjacent to the Loren Terry Pump Site (Figure 9). Because this was the preferred site for the submerged intake design, data from this cross section was evaluated in terms of intake design dimensions and channel constrictions. Minimum flows assuring safe navigation and adequate pump operation are dependant on the location of the intake structure in the river channel. Six hypothetical locations were chosen and the minimum flows determined (Figure 20). At location C, a minimum flow of 4000 cfs at Virgelle would be required as an operable flow and 7500 cfs at location D. In low flow years as in 1985 neither of these locations would provide adequate water depth above the intake, given the design criteria. Accommodating low flow conditions would necessitate locating the submerged intake structure near the middle of the channel. Locating the intake at point A would require a minimum flow of 1000 cfs at the Virgelle gage.

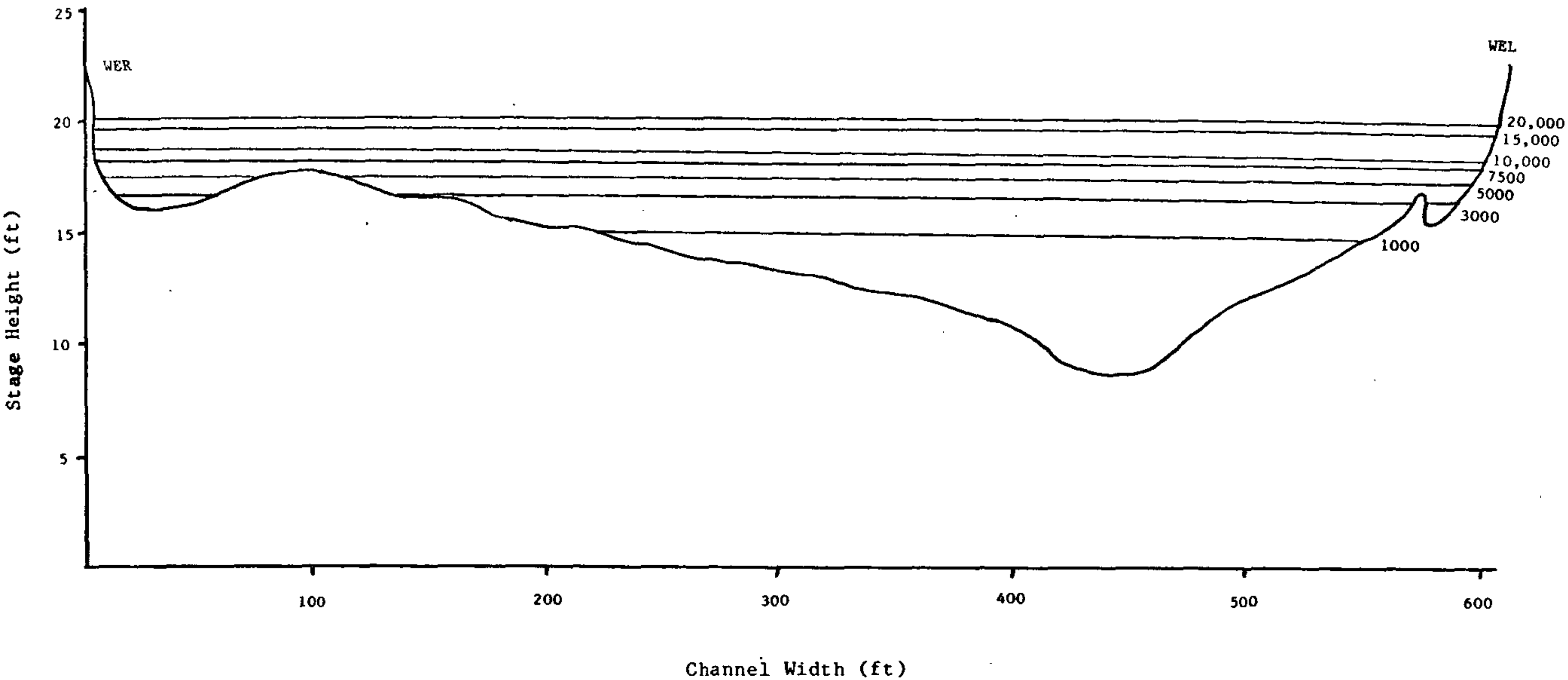


Figure 19. Wetted-perimeter cross section 1 facing upstream, located in the main channel of the Missouri River in the vicinity of the Loren Terry Pump Site. River stage heights for select Virgelle gaged flows (cfs) are included.

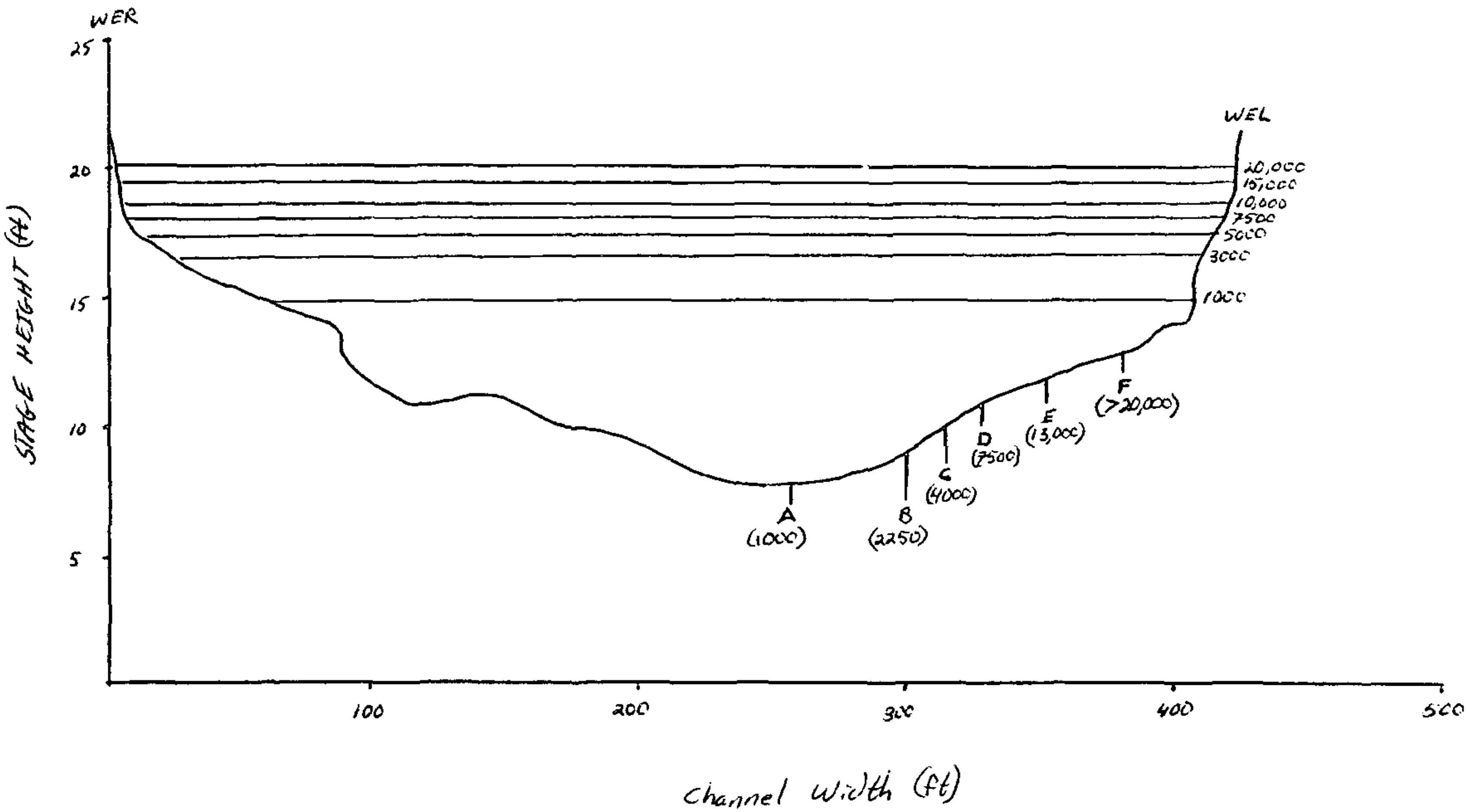


Figure 20. Wetted perimeter cross section 2 facing upstream, located in the main channel of the Missouri River adjacent to the Loren Terry Pump Site. River stage heights for select Virgelle gaged flows (cfs) are included along with 6 hypothetical points for locating a submerged intake. Minimum flows (cfs) for each location appear in parentheses.

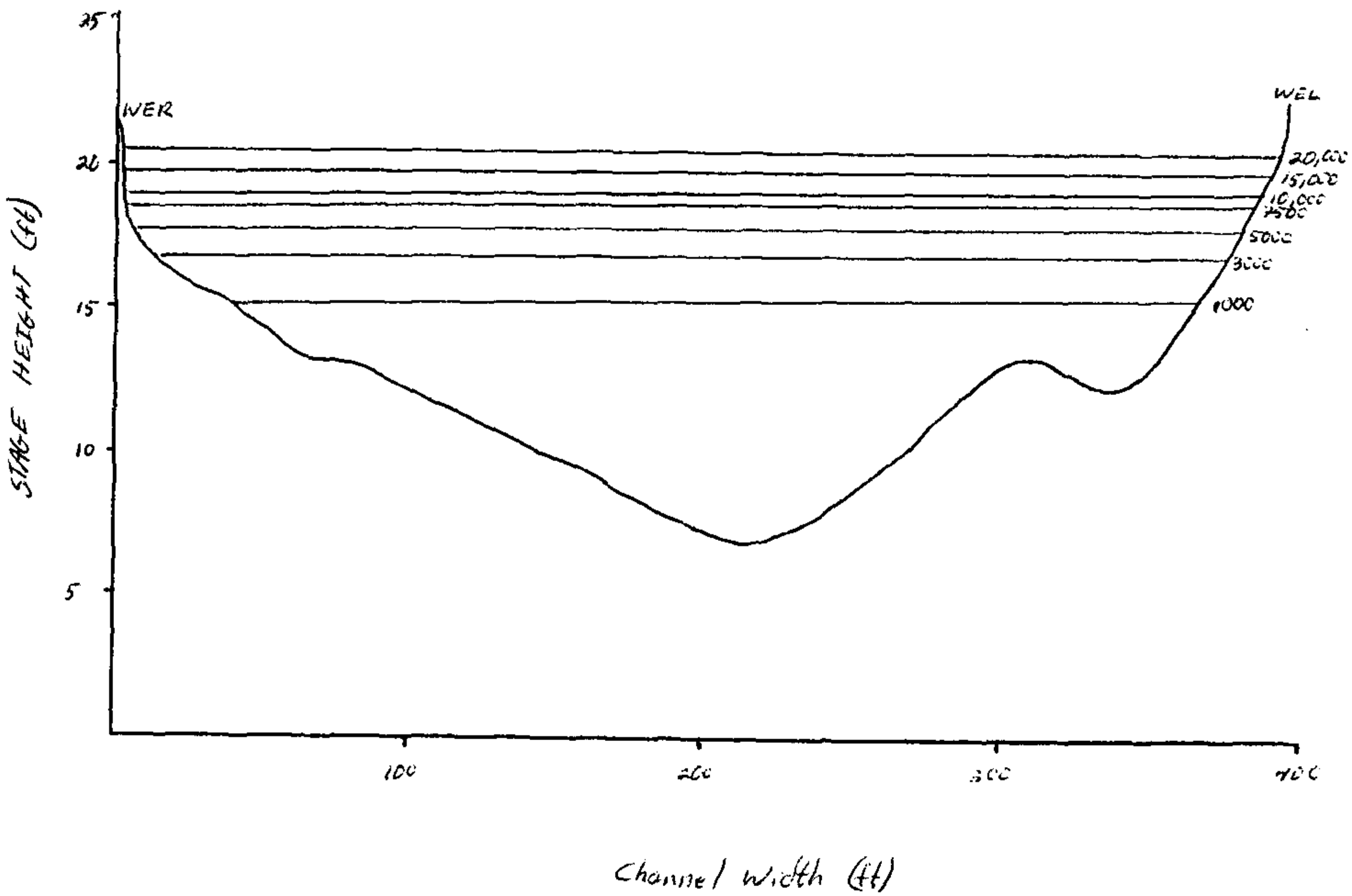


Figure 21. Wetted-perimeter cross section 3 facing upstream, located in the main channel of the Missouri River in the vicinity of the Loren Terry Pump Site. River stage heights for select Virgelle gaged flows (cfs) are included.

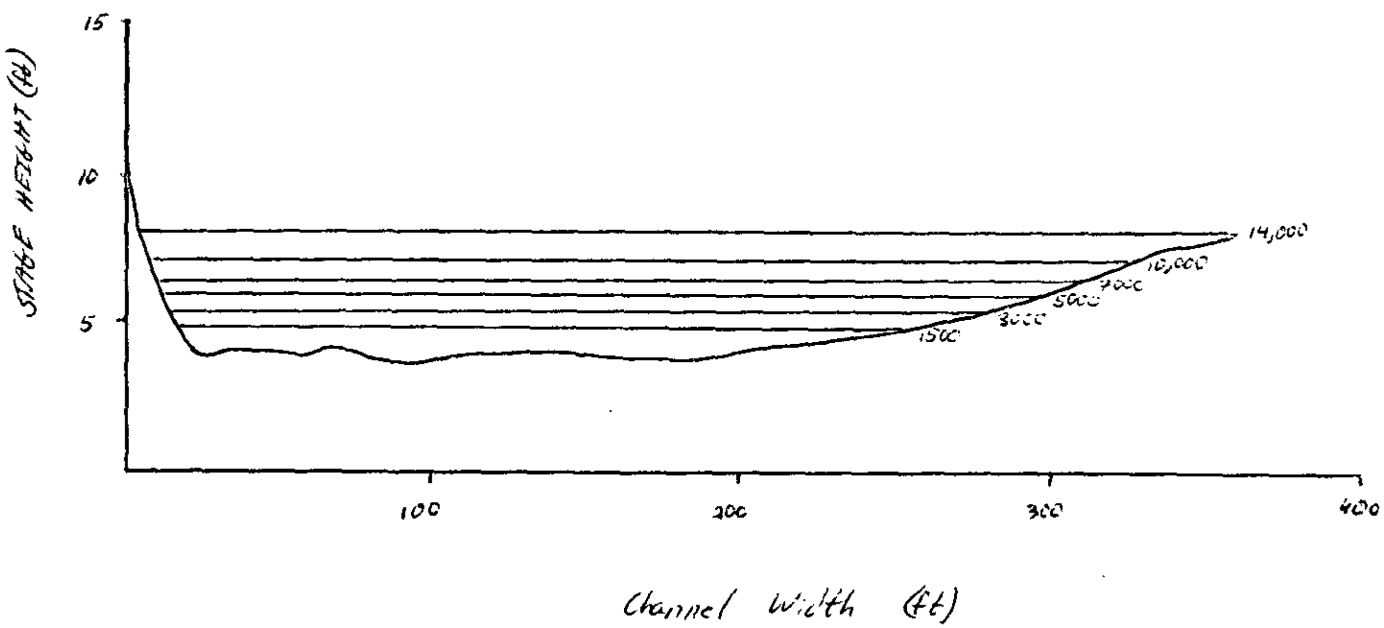


Figure 22. Wetted-perimeter cross section facing upstream, for the bypass channel associated with the Loren Terry Pump Site on the Missouri River. River stage heights for select Virgelle gaged flows (cfs) are included.

Big Sandy Creek

Larval Fish

Larval fish were sampled at four sites on Big Sandy Creek and one site on Box Elder Creek (Table 11). Box Elder Creek is a major tributary capable of contributing ichthyofauna to Big Sandy Creek. The locations of larval fish sampling stations are indicated on Figure 4. Larval fish were sampled on 14 dates in Big Sandy Creek and four dates on Box Elder Creek. Sampling was initiated 2 May, 1985, and continued until 4 June, 1985, at which time flows became insufficient for this type of passive sampling.

White suckers comprised 88 percent of all larvae collected. Cyprinids (10 percent) and northern pike (2 percent) were the only other taxons represented in larval fish samples. White sucker and cyprinid larvae were taken at all stations while northern pike were only captured on 13 May, at Station B. Sampling sites A and B exhibited the largest catches of white sucker larvae. Site B produced the highest diversity and mean density of larval fish in the study area.

The larval fish catch from Box Elder Creek was similar to that from Big Sandy Creek Station (D). Box Elder Creek did not contribute to species diversity or significantly affect abundance of larval fish in Big Sandy Creek in 1985. A kick-net sample was taken at station B on 2 May. The net was pushed through flooded shoreline vegetation to dislodge and capture northern pike fry which often attach themselves to vegetation shortly after hatching (Scott and Crossman, 1973). Approximately 150 feet of shoreline vegetation was sampled without success. Given the size of northern pike captured 13 May, it is likely that by this time the larvae had matured past the adhesive stage.

Fish Populations

Fifteen species representing five families of fish were sampled in the study area. Five species were found only in the extreme lower reach. Species composition and distribution of fishes found in the study area are shown in Table 12. As was described earlier, two reaches having distinct habitat types are present in the study area. Fish populations of each reach are discussed separately.

Upper Reach - River Mile 1.8 to 50.7

Conditions for over-winter fish survival were poor in 1984. Prior to ice cover, Big Sandy Creek consisted of shallow isolated pools. No observations were made at ice-out but winterkill was undoubtedly significant despite the hardiness of indigenous species. Northern pike and black bullhead provide the only sport fishing in this reach. Fishing pressure is low consisting mostly of local anglers. Fishermen reported catching fair numbers of northern pike 15-20 miles above the mouth in 1983. Seining and electrofishing in 1985 confirmed the presence of juvenile and adult pike as far as 30 miles upstream from the mouth. These fish probably over-wintered in the deeper scour holes common below bridges and culverts on the creek.

Northern pike require the presence of vegetation in order to spawn successfully (Fabricus and Gustafson 1958). This is often in the form of flooded terrestrial

Table 11. Density of larval fish collected per $100 m^3$ of water sampled from all larval fish sampling stations within the study area, 1985. (Numbers of larvae captured in parentheses.)

Station Location	River Mile 1/	Sampling Period	No. of Samples	Total Volume Sampled (m^3)	*Esox lucius*	*Catostomus commersoni*	Cyprinidae	Total Larvae
A Big Sandy Creek T32N R15E S5	1.9	5/2-6/4	14	302	0 (0)	5.3 (16)	1.0 (3)	6.3 (19)
B Big Sandy Creek T32N R14E S34	15.8	5/2-6/4	14	563	0.4 (2) 2/	9.6 (54)	0.2 (1)	10.1 (57)
C Big Sandy Creek T31N R14E S29	20.0	5/2-6/4	14	419	0 (0)	0.5 (2)	0.2 (1)	0.7 (3)
D Big Sandy Creek T31N R14E S32	29.4	5/2-6/5	13	198	0 (0)	2.0 (4)	1.0 (2)	3.0 (6)
E Box Elder Creek at Hwy 87 crossing		5/6-5/28	4	180	0 (0)	1.1 (2)	1.1 (2)	2.2 (4)

1/ River mile index of the Missouri River, MT Dept. of Natural Resources, 1979.

2/ Early Juveniles (24-27mm).

Table 12. Species composition and relative abundance ratings for fishes found in Big Sandy Creek below the town of Box Elder, April-August, 1985.

	rating[1]
Esocidae	
Esox lucius - Northern pike	C
Cyprinidae	
Phoxinus eos - Northern redbelly dace	U
Couesius plumbeus - Lake chub	C
Notropis atherinoides - Emerald shiner[2]	A
Hybognathus hankinsoni - Brassy minnow	R
Hybognathus sp. - Silvery/plains minnow	C
Pimephales promelas - Fathead minnow	C
Rhinichthys cataractae - Longnose dace	U
Notropis hudsonius - Spottail shiner[2]	R
Catostomidae	
Catostomus commersoni - White sucker	A
Ictaluridae	
Ictaluras melas - Black bullhead	A
Percidae	
Perca flavescens - Yellow perch[2]	A
Stizostedion canadense - Sauger[2]	C
Stizostedion vitreum - Walleye[2]	C
Etheostoma exile - Iowa darter	R

[1] A = Abundant
C = Common
U = Uncommon
R = Rare

[2] Found only in extreme lower reach.

vegetation. Endogenous-feeding larvae attach to vegetation for a short time after hatching. Even modest flows in spring inundate shoreline grasses along this entire reach. Rapid dewatering of this flooded vegetation after peak runoff is probably more limiting to spawning success than the lack of suitable spawning substrate. Resident northern pike were not abundant but a sufficient number were present to achieve successful reproduction as shown by larval fish sampling and beach seining.

The vegetated pools and gravel riffles provide suitable spawning substrate for cyprinids and catostomids.

The minnows and suckers sampled in this reach are common to most streams in the area. However, the absence of brook sticklebacks (Culaea inconstans) is unusual in light of their local abundance and hardiness. Fathead minnows dominated the catch in both sampling periods (Table 13). The brassy minnow and Iowa darter appear to be in limited numbers with a reduced distribution. All other species found in this reach appear to have significant base populations and are widely distributed.

Lower Reach - Mouth to River Mile 1.8

This reach is greatly affected by irrigation water releases from Fresno Reservoir. At high Milk River flows the entire reach becomes a quiet backwater pool. At low Milk River flows it returns to a pool-riffle configuration. Although high vertical banks border much of this reach, low grassy benches or berms are common and provide suitable spawning substrate for northern pike. An abundance of aquatic vegetation borders the banks and a deep mid-stream channel allows for movement within the reach during low water conditions. Cover is abundant in the form of dense aquatic vegetation, overhanging brush, and undercut banks.

Water clarity is variable but turbidity is usually less than that found in the adjacent Milk River. Although pike occur in a wide range of habitats, they are usually more successful in areas where little energy is expended for swimming, suitable cover is available for ambush, and clear water facilitates visual prey detection. Only creek mouths and backwater areas similar to that found in Big Sandy Creek provide this kind of habitat in the Milk River system. The close relationship with the Milk River is probably responsible for the presence of five fish species not found in the upper reaches of Big Sandy Creek.

Adult northern pike were common in the catch. Three YOY were captured during the last sampling period and others were observed in aquatic vegetation. A total of 50 adult pike were captured and 42 were subsequently tagged and released. Northern pike were originally tagged to monitor upstream spawning movements, however, spring runoff was of insufficient duration and magnitude to initiate a spawning run.

Pike in the sample ranged from 0.14 to 7.76 kilograms. Three fish tagged in the spring were recaptured in late summer in the same area. Fishermen returned two tags, both caught near the site. These tag returns indicate a substantial pike population inhabits the lower reach. Numbers may be augmented during the spring spawning period as Big Sandy Creek provides the only suitable spawning habitat for a considerable distance.

Table 13. Summary of fish captured by seining in upper reach of Big Sandy Creek during spring and summer sampling periods. Catch per unit effort (CPUE) expressed as number of fish per 100 linear feet of stream.

Species	Spring-2780 feet No. sampled	Spring-2780 feet CPUE	Summer-870 feet No. sampled	Summer-870 feet CPUE	Totals-3650 feet No. sampled	Totals-3650 feet CPUE
Northern pike	3	0.1	4	0.5	7	0.2
Northern redbelly dace	3	0.1	57	6.6	60	1.6
Lake chub	356	12.8	61	7.0	417	11.4
Brassy minnow	1	0.1	0	-	1	0.1
Silvery/plains minnow	66	2.4	45	5.2	111	3.0
Fathead minnow	1,586	57.1	120	13.8	1,796	46.7
Longnose dace	106	3.8	8	0.9	114	3.1
White sucker	30	1.1	80	9.2	110	3.0
Black bullhead	4	0.1	8	.9	12	0.3
Iowa darter	2	0.1	5	.6	7	0.2

No adult walleye or sauger were captured during any of the sampling periods, possibly due to the bottom-dwelling characteristics of the fish or inefficiency of the sampling gear. A more plausible explanation is that the Milk River is a more preferred habitat. A normal spring discharge from Big Sandy Creek may allow walleye to ascend the creek and extend their distribution. Walleye YOY were observed while electrofishing. Walleye and sauger YOY were captured by beach seining in late summer. The limited amount of seining conducted was hampered by deep mud, vegetation, and debris. However, the catch indicates a substantial number of walleye/sauger YOY are utilizing this area for rearing.

Electrofishing revealed large numbers of yellow perch YOY and emerald shiners in the dense vegetation throughout the reach. No effort was made to quantify forage fishes in this short reach. However, a limited amount of seining captured numerous adult, juvenile, and YOY forage fishes. Species captured are listed in decreasing order of abundance: emerald shiner, yellow perch, white sucker, silvery/plains minnow, black bullhead, lake chub, and brassy minnow. A single yearling spottail shiner was also captured. This species was introduced into Fresno Reservoir in 1984 and is not native to the state.

Painted turtles, (Chrysemys picta), molluscs (Anodonta grandis and Sphaerium striatinum), and crayfish (Orconectes virilis) were in such great abundance throughout the study area that their presence should be noted.

SUMMARY OF FINDINGS

Missouri River

1. The objectives of this portion of the study could not be adequately addressed due to extreme low flow conditions in the middle Missouri River in 1985.

2. Paddlefish did not migrate up the Missouri River to known concentration areas in 1985. Spring flows peaked briefly at 11,000 cfs for the Virgelle gaged reach of the Missouri. A flow of 14,000 cfs for this river reach has been identified as the threshold flow necessary to trigger a paddlefish spawning migration (Berg 1981).

3. Sauger and shovelnose sturgeon were the most abundant gamefish collected during electrofishing surveys. While the relative abundance of these species was similar to past studies on the Missouri River, spawning success was not confirmed during larval fish sampling. Important shovelnose sturgeon concentration areas were located and habitat characteristics identified.

4. Larval fish sampling in 1985 was the most intense ever conducted on the middle Missouri River, however, fewer taxa were collected than in past studies. Catostomids comprised 99% of the larvae collected. No sauger, shovelnose sturgeon or paddlefish larvae were collected. The average larval fish density for survey samples was 15.6 larvae/100m^3. Berg (1981) found the highest density of larval fish in the entire middle Missouri River near Coal Banks landing with an average density of 306.8 larvae/100m^3. In 1985 the highest mean density of larval fish was found at the Six Mile Coulee survey site (25.1 larvae/100m^3).

5. Larval fish abundance fluctuated from week to week with several prominent peaks. The period from early May through mid-July under the low flow conditions experienced in 1985, was the critical interval for the presence of fish larvae within the study area.

6. Intense horizontal larval fish sampling near the Loren Terry Pump Site indicated certain trends in larval fish distribution. Overall, larval fish were most abundant along the left bank. Cyprinid larvae were most often associated with the right bank where current velocities were less.

7. Intense vertical larval fish sampling near the Loren Terry Pump Site indicated that larval fish density was significantly ($p < 0.05$) greater in surface samples than from those collected at mid-depth or off the bottom.

8. Variation in larval fish abundance based on current velocity orientation indicated that to some extent, differential current preference exists between taxa.

9. Diel variation in larval fish abundance was documented. Considerably greater numbers of larvae were present in the drift during midnight and dawn sampling periods than during noon and dusk periods. Some variation in diel drift patterns were identified among taxa.

10. Young-of-the-year and forage fish were extremely abundant in seining samples in 1985. Assuming poor reproductive success for most species based on larval fish data, it is believed that high YOY and forage fish abundance was due to their being concentrated in limited rearing areas as a result of low flow conditions.

11. Approximately 25 percent of the flow bypasses the main channel at the Loren Terry Pump Site. A Virgelle gaged flow of 1500 cfs is necessary to provide adequate stream depth and width for floaters using the bypass channel. Power boats would require a flow of 7000 cfs to safely navigate the bypass channel.

12. While the exact dimensions of the submerged intake structure were not available, it was determined that at least seven feet of water would be required to safely locate the structure in the river channel. Several hypothetical positions were evaluated at the Loren Terry Pump Site. It is evident that low flow conditions similar to those experienced in 1985 could constitute a significant problem for locating a submerged intake structure.

Big Sandy Creek

1. The objectives of this portion of the study could not be adequately addressed due to drought conditions present during the study period.

2. The unusually harsh overwinter conditions in Big Sandy Creek probably reduced species diversity, population size, and distribution to an extremely low level.

3. Despite meager spring flows and summer dewatering, successful reproduction of resident species occurred. Sufficient habitat is present in the creek to provide some spawning potential even in low water years.

4. Spring flows appeared insufficient to initiate any migratory runs of fish from the Milk River, however, reproduction of resident fishes in both reaches of Big Sandy Creek was documented for sport and forage species.

5. The lower two miles of Big Sandy Creek were found to be an important spawning/rearing area for many sport and forage fishes. This type of habitat is scarce in the upper Milk River drainage and must be considered a critical habitat area.

DISCUSSION

Pump Site Options

Site selection is critical considering the exceptional historic, recreational, scenic and natural values of this section of the Missouri River. A unique and environmentally sensitive aquatic ecosystem exists and every effort should be made to protect these valuable fishery resources. Larval fish data were collected at two of the four alternative pumping sites (Virgelle, Site 1 and Virgelle, Site 2) during the 1985 field season. No data are available for either the Boggs Island, Site 1 or the Boggs Island, Site 2 locations because these sites were selected after larval fish sampling had been completed. Because comparable larval fish data were not collected, it is not possible to make a statistical comparison of the four alternative pumping plant sites in regard to larval fish production. Overall, low larval fish densities resulting from the drought conditions experienced in 1985 further complicated the determination of larval fish production within the study area.

Virgelle Site 1

This site, commonly referred to as the Loren Terry Pump Site throughout this report received the most research effort in 1985 as this was the preferred site when this study was initiated. Larval fish dynamics were described and the channel hydraulics and dimensions documented. Larval fish abundance was highest along the left bank. While larval fish dynamics were described in detail at this location, the extreme low flow conditions in 1985 resulted in an insufficient data base. Locating the pumping plant at this site would not impact key spawning or rearing areas.

Virgelle Site 2

This site, just downstream from the Virgelle Site 1 location would require major bank stabilization work as the river is severely eroding the left bank. A larval fish survey site was located adjacent to this site. Low larval fish density was attributed to the swift current associated with the channel in this area. Shovelnose sturgeon were found to congregate in this area during late spring and summer. Little rearing habitat exists at this site and key spawning areas could not be identified.

Boggs Island Site 1

This site, just upstream from Boggs Island, is located in a known paddlefish concentration area during spring migrations (Berg 1981, Gardner and Berg 1982). Activities associated with the construction and operation of a pumping plant at this site could be detrimental to this habitat. A single larval fish survey site was located just upstream from this site and the highest density of larval fish within the study area was found here.

Key rearing areas for YOY fish and forage species were not found at this site. Downstream from the Boggs Island Site 1 location the main channel adjacent to Boggs Island has been identified as an important shovelnose sturgeon concentration area. The abundance of silt-free gravel/cobble substrate appeared to provide ideal foraging conditions. Construction, operation, and maintenance of a pumping plant could have detrimental effects on this habitat.

Boggs Island Site 2

This site is located in the side channel behind Boggs Island. The Boggs Island side channel is characterized by having an abundance of silt-free gravel/cobble substrate. This side channel would appear to provide ideal spawning habitat for certain species. Seining results indicated that this site was not a key rearing area. Locating a pumping plant behind Boggs Island would reduce the visual impacts of the pumping plant.

Intake Design Options

Rates of entrainment and impingement of aquatic resources are directly related to intake velocities at and around the intake structures, and also to numerous other physical and biological phenomena (Boreman 1977). The Environmental Protection Agency (1973) recommends intake velocities of less than 0.15 m/s (0.5 ft/s) should be maintained to avoid fish impingement or entrainment. The location of the intake structure in relation to shoreline, bottom, and water surface will influence the abundance, variety and extent of withdrawal of aquatic organisms. Biological phenomena that influence the magnitude of entrainment and impingement of aquatic organisms include their: (1) motility; (2) physiological and behavioral responses to factors such as temperature, oxygen concentration, currents, etc.; (3) vertical and horizontal distribution in the vicinity of the intake; and (4) growth rate which governs the period of vulnerability to entrainment or impingement during each life stage (Boreman 1977).

Findings from the larval fish study in 1985 indicate that variation in drift characteristics exist between species. Periods of vulnerability, diel fluctuation in abundance, and current velocity orientation are a few of the parameters associated with this variation. As previously stated, low flow conditions in 1985 resulted in decreased spawning activity and hatching success for most species. The species of greatest importance as related to this project, paddlefish, sauger and shovelnose sturgeon, were not represented in larval fish collections. Because drift dynamics of larval fish are species-specific, the limited findings from this study cannot be extrapolated for those species not collected. Larval fish data collected from the middle Missouri River in 1985 is not sufficient baseline data for predicting potential fish losses due to entrainment or impingement.

The potential to transfer fish species between the Missouri River and the upper Milk River is dependent primarily on the intake design of the pumping plant. Presented here is a high potential scenerio assuming all fish species currently found or expected to inhabit the middle Missouri River would be transferred to the upper Milk River drainage. Table 14 contains a list of fish species exotic to the upper Milk River with some reasonable probability of transfer by this project. The sturgeon, paddlefish, goldeye, and all of the salmonids listed have sportfish value but, given the habitat restrictions, are not expected to establish in this reach of the Milk River. Channel catfish and freshwater drum would be expected to establish residence and contribute to the sport fishery.

Table 14. A list of fish species not known to occur in the Milk River drainage upstream from the Havre water weir that may be introduced during interbasin transfer of water from the middle Missouri River.

Acipenseridae
- *Scaphirhyncus albus* - Pallid sturgeon
- *Scaphirhyncus platorynchus* - Shovelnose sturgeon

Polyodontidae
- *Polyodon spathula* - Paddlefish

Hiodontidae
- *Hiodon alosoides* - Goldeye

Salmonidae
- *Oncorhynchus tshawytscha* - Chinook salmon
- *Oncorhynchus nerka* - Kokanee
- *Salvelinus namaycush* - Lake trout
- *Coregonus artedii* - Cisco

Cyprinidae
- *Cyprinus carpio* - Carp
- *Carassius auratus* - Goldfish
- *Hybopsis gelida* - Sturgeon chub
- *Hybopsis meeki* - Sicklefin chub
- *Gila atraria* - Utah chub

Catostomidae
- *Carpoides carpio* - River carpsucker
- *Cycleptus elongatus* - Blue sucker
- *Ictiobus bubalus* - Smallmouth buffalo
- *Ictiobus cyprinellus* - Bigmouth buffalo
- *Moxostoma macrolepidotum* - Shorthead redhorse

Ictaluridae
- *Ictalurus punctatus* - Channel catfish

Sciaenidae
- *Aplodinotus grunniens* - Freshwater drum

All of the cyprinids and catostomids have some potential to establish in the upper Milk River or Big Sandy Creek. One species, carp, is of particular concern. Carp are highly adaptable and have a high probability of transfer. Carp are considered detrimental to native fish populations because they increase the turbidity of the water and uproot and destroy submerged aquatic vegetation that is essential for the survival of sport and forage fish (Scott and Crossman 1973). As previously stated, suitable spawning habitat for northern pike is limited in the Milk River below Fresno dam. The Big Sandy Creek backwater area with its submerged aquatic vegetation and flooded terrestrial vegetation, provides what is otherwise very limited habitat in the Milk River. The feeding behavior of carp would be expected to adversely impact this critical habitat.

The introduction of carp into this reach of the Milk River would extend their range to Fresno Dam, increasing the chances of a bucket transfer to Fresno Reservoir. Once in Fresno Reservoir, carp would have access to waters in Alberta, Canada. This would be significant considering that carp have not been found in this province (Willock 1969). The Milk River between Fresno dam and the Havre water weir is a somewhat unique stretch of river in regards to the fish community. Several rough fish species commonly found in lower sections of the Milk and in other rivers in eastern Montana, have not been collected in this section of the Milk. While the impacts from the transfer of other species is not expected to be as severe as the carp, their introduction would be expected to alter the unique fish community assemblage of this reach.

Submerged Intake Design with Johnson Screens

This design has less potential to impinge or entrain fish larvae than an open intake design due to the reduced intake velocity provided by the Johnson screens. However, entrainment and/or impingement is not eliminated and there is a high probability of transfer of fishes from the Missouri River to the Milk River below Fresno dam. An attempt was made to estimate fish losses using computer models. Mathematical models have been developed (Horst 1975, Rago 1984, and Goodyear 1977, 1978) to estimate fish losses associated with various intake structures. Insufficient larval fish data resulting from the record low flows experienced in 1985 precluded the use of those models for predicting potential fish losses.

The exact dimensions of the submerged intake structure were not available, however, it is surmised that at least seven feet of water would be necessary to safely operate this design. It has been demonstrated that during low flow years channel dimensions may be somewhat constraining for this design option. The potential exists for this structure, depending upon its location, to pose a navigational hazard to recreational boaters.

Infiltration Gallery

This design should eliminate or greatly reduce the potential for transferring fish from the Missouri River to the Milk River. It would not require a physical obstruction in the stream channel and would eliminate the need for a minimum depth of water over the intake structure.

Considerable in-channel construction activity would be required to develop the infiltration gallery. This activity has the potential to cause significant short-term impacts. The construction site is in a known paddlefish concentration area and immediately above a substantial riffle area. Every effort should be made to minimize sedimentation and other impacts associated with construction.

The percolation bed of the infiltration gallery may periodically become clogged by sediment. This will require a backflushing system. Since the Missouri transports large quantities of sediment, siltation could be a significant maintenance concern. The potential for siltation at the site should be investigated and the frequency and probable timing of backflushing determined. The effect of backflushing on downstream foraging and rearing areas should be examined.

With regard to the potential for entrainment of larval fish and transfer from the Missouri to the Milk river, the infiltration gallery would be the preferred design alternative. The question of contruction impacts and the effects of periodic backflushing, however, need to be addressed.

Canal Route Options

Supplemental water transferred through any of the alternative canal routes will ultimately discharge into the Milk River at some location along a 16.5 mile reach from Fresno dam to the Havre water weir. The water weir is not a particularly imposing structure, however, its design has been effective in preventing the upstream migration of fishes, particularly carp. The entire Milk River system in encumbered with large diversion dams which inhabit upstream movement of fishes, thereby limiting distribution.

It is important to discuss the fishery potential of Big Sandy Creek in light of its relationship to the Milk River. Rainbow trout and whitefish are common in the Milk River immediately below Fresno dam. These fish are actively pursued by spin and fly-fishermen in the major pools below the dam. The remainder of the reach contains a diversity of fishes similar to those found in Big Sandy Creek. Data concerning species composition, abundance, and distribution from the Fresno dam to Havre water weir reach is sketchy. A species list was compiled and relative abundance ratings assigned utilizing data from four spot collections made within the reach in 1960, 1976, 1983, and 1985 (Table 15). By nature, abundance ratings are subjective, but are used here to indicate proportional occurrence of fish species within this reach. At least 12 fish species presently found in the lower Milk River have not been observed in this reach.

Most fishing pressure is limited to the pools immediately below Fresno dam and the mouth of Big Sandy Creek, although float fishermen occasionally fish the more remote areas of the reach. Within this reach, approximately nine miles of river frontage on the north bank is owned by the Department of Fish, Wildlife and Parks. Accessibility is good and two fishing access sites for canoe launching are present. Occasionally large walleye over 4.5 kilograms and northern pike up to 9.0 kilograms are taken below the dam. In 1983 a walleye that exceeded the state record was electrofished from a pool below Fresno dam. Lower Big Sandy Creek occasionally produces large catches of northern pike, black bullhead, and yellow perch. Trophy-size northern pike are also present.

Table 15. Species composition and relative abundance ratings for fishes found in a 16.5 mile reach between Fresno Dam and the Havre city water weir.

	rating[1]
Salmonidae	
Salmo gairdneri - Rainbow trout	C
Coregonus clupeaformis - Lake whitefish	C
Prosopium williamsoni - Mountain whitefish	R
Esocidae	
Esox lucius - Northern pike	C
Cyprinidae	
Phoxinus eos - Northern redbelly dace	C
Hybopsis gracilis - Flathead chub	U
Couesius plumbeus - Lake chub	U
Notropis atherinoides - Emerald shiner	A
Hybognathus hankinsoni - Brassy minnow	U
Hybognathus placitus - Plains minnow	R
Hybognathus argyritis - Western silvery minnow	C
Pimephales promelas - Fathead minnow	C
Rhinichthys cataractae - Longnose dace	C
Catostomidae	
Catostomus catostomus - Longnose sucker	C
Catostomus commersoni - White sucker	A
Ictaluridae	
Ictaluras melas - Black bullhead	U
Noturus flavus - Stonecat	C
Gadidae	
Lota lota - Burbot	R
Centrarchidae	
Micropterus dolomieui - Smallmouth bass	R
Pomoxis nigromaculatus - Black crappie	U
Percidae	
Perca flavescens - Yellow perch	C
Stizostedion canadense - Sauger	C
Stizostedion vitreum - Walleye	C
Etheostoma exile - Iowa darter	U

[1] A = Abundant
C = Common
U = Uncommon
R = Rare

At least six large riffles of gravel and rubble exist in this reach of the Milk River and may provide suitable walleye/sauger spawning substrate. Spawning habitat (i.e. grasses, brush) required for species such as yellow perch and northern pike is scarce. The potential for successful spawning in this reach is further reduced by low flows present during early spring. At this time of the year, Fresno Reservoir is filling and 80% of available spawning substrate may be dewatered.

Fresno Reservoir has the potential to produce large numbers of walleye, northern pike, and yellow perch under favorable water conditions. Recruitment from Fresno Reservoir discharges is thought to be significant in most years. The extreme drawdowns that occur annually are known to flush large numbers of larval fish downstream. Because of poor northern pike reproduction in Fresno Reservoir in 1985, northern pike YOY found in Big Sandy Creek probably originated there. Sauger are rarely found in Fresno, yet YOY were common in Big Sandy Creek. The walleye YOY captured in Big Sandy Creek may have originated in the Milk River, Fresno Reservoir, or Big Sandy Creek.

Though recruitment from Big Sandy Creek may not be as important in years of high production from Fresno Reservoir, in the last three years, the creek has provided the only northern pike production for the reach. Big Sandy Creek has also produced large numbers of forage fish that have not been present in Fresno Reservoir for several years.

Beaver Creek is the only other significant tributary entering within this reach of the Milk River. Due to channelization of the lower end, it provides limited spawning and rearing potential.

Westside Canal Route

This option should have no adverse affect on fish populations in Big Sandy Creek. The lower reach would retain its integrity as an important rearing area. The potential for a lateral drop of water into Sage Creek to supplement summer flows in Big Sandy Creek presents itself with this option.

Eastside Canal Route

This option minimizes impacts in the upper reach of Big Sandy Creek but would empty the full flow of the canal into the lower reach. This reach is currently utilized as a rearing area by a variety of sport and forage fish due to its backwater nature. A flow of 300 cfs would render the reach unsuitable for rearing of important sport and forage species.

Creek Route

This option would utilize the lower 21 miles of Big Sandy Creek as a conveyance facility for project water. The creek might benefit from some additional water (10-25 cfs) during the summer months but the instability of the drainage precludes its use for sustained flows over 25 cfs. The creek route option would place 300 cfs in the creek for over 5 months. Flows of this magnitude would uproot or flood streamside vegetation. Dewatering of these areas in the fall or early winter would not allow for revegetation prior to next season's flows. Natural periodic flows over 1000 cfs occur but are of short duration allowing an entire growing season(s) for regrowth and stabilization.

Massive sediment transport into the Milk River could be expected. The Milk River is currently a highly errosive, dynamic system. The addition of large amounts of sediment may hasten channel changes in the Milk River. Calm water species such as northern pike, black bullhead, and yellow perch would decline or disappear in Big Sandy Creek as the pool-riffle habitat in the upper reach changes to long, fast runs. The lower reach rearing area, which is also of extreme importance to the Milk River, would be lost due to the change from pool to run.

If a sediment trap is placed near the mouth, the significant acreage required would most likely cover the entire lower reach. Even if such a trap was designed for upstream fish movement, habitat degradation upstream would negate spawning or rearing attempts.

Railroad Canal Route

This option would have no adverse affect on Big Sandy Creek. This route courses between the Big Sandy Creek and Beaver Creek drainages and presents the possibility of a lateral drop of water into the Beaver Creek near Fort Assinniboine. Lower Beaver Creek suffers annually from dewatering and supplemental water may significantly benefit the fishery in the lower ten miles.

All canal route options have the same potential for ichthyofauna transfer. Saline seep is an issue that warrants further study. The eastside, westside and railroad canal route options could have adverse impacts on Big Sandy Creek if saline seep becomes a problem.

ADDITIONAL RESEARCH NEEDS

Fisheries research related to the Milk River Water Supply Project in 1985 was directed towards assessing the potential fisheries impacts associated with a submerged intake design located at the Virgelle Site (Loren Terry Pump Site). Recent changes in plans by the Bureau of Reclamation include relocating the pumping plant to above Boggs Island and utilizing an infiltration gallery as the intake design. The Boggs Island Site has been identified as an important concentration area for paddlefish during spring migrations (Berg 1981, and Gardner and Berg 1982). It will be necessary to ascertain whether this is in fact a spawning site, or simply a staging area for paddlefish spawning in the middle Missouri River.

Only scant fisheries data was collected at the Boggs Island site during the 1985 field season, as efforts were directed towards the Virgelle site. Relocation of the pumping plant will necessitate additional fisheries study to address potential impacts at the Boggs Island Site. These efforts should include intense spring electrofishing to identify paddlefish concentration areas. Once identified efforts in those areas should include kick-net sampling for eggs and drift net sampling for larvae. River dimensions at this site should be mapped using wetted perimeter techniques. Habitat characteristics that should be evaluated include current velocity profiles and substrate analysis. Determination of channel dimensions and habitat characteristics would be used to document site changes associated with the construction and operation of a pumping plant.

Several questions need to be addressed concerning the construction and operation of the infiltration gallery. Potential construction impacts include increased sediment production and impacts related to instream construction activities. The frequency and effect of backflushing also need to be addressed.

Several of the canal route options will utilize Big Sandy Creek for the conveyance of project water. Key rearing areas in the lower end of Big Sandy Creek would be eliminated. This loss of habitat will require mitigation. The saline-seep issue is one that will require further consideration. Three of the four canal route options would have the potential to impact Big Sandy Creek should saline-seep pose a problem.

Additional water in the Milk River System might be beneficial to the fisheries in Fresno and Nelson reservoirs under certain conditions. Water level management plans for Nelson and Fresno reservoirs should be prepared. Water management plans should include a water withdrawal schedule for the Missouri River and a discussion of the likelihood of supplemental water supplied from Tiber reservoir. The water management and regulation plan should be evaluated to determine its effect on the fishery resources of the area.

LITERATURE CITED

Bailey, R.M., and H.M. Harrison, Jr. 1948. Food habits of the southern channel catfish (Ictalurus lacustris punctatus) in the Des Moines River, Iowa. Transactions of the American Fisheries Society, 75:110-138.

Balon, E.K. 1975. Reproductive guilds of fishes: A proposal and definition. Journal of Fisheries Research Board of Canada, 32(6): 821-864.

Berg, R.K. 1981. Fish populations of the Wild and Scenic Missouri River, Montana. Montana Department of Fish, Wildlife and Parks. Federal Aid to Fish and Wildlife Restoration Project FW-3-R. Job Ia. 242pp.

Boreman, J. 1977. Impacts of power plant intake velocities on fish. FWS/OBS-76/20.1. U.S. Fish and Wildlife Service. Department of the Interior, Washington, DC. 10pp.

Brown, C.J.D. 1971. Fishes of Montana. Big Sky Books, Montana State University, Bozeman, Montana 207pp.

Buchanan, T.J. and W.P. Somers. 1969. Techniques of water-resources investigations of the United States Geological Survey. Discharge measurements at gauging stations. Book 3, Applications of Hydraulics. United States Government Printing Office, Washington D.C. 65pp.

Clifford, H. 1972. Downstream movements of white sucker, Catostomus commersoni, fry in a brown-water stream of Alberta. Journal of Fisheries Research Board of Canada, 29: 1091-1093.

Emery, A.R. 1973. Preliminary comparisons of day and night habits of freshwater fish of Ontario Lakes. Journal of Fisheries Research Board of Canada, 30: 761-774.

Fabricius, E., and K.J. Gustafson, 1958. Some new observations on the spawning behavior of pike, Esox lucius L. Rep. Inst. Freshwater Res. Drottningholm 39:23-54.

Floyd, K.B., R.D. Hoyt, and S. Timbrook. 1984. Chronology of appearance and habitat partitioning by stream larval fishes. Transactions of the American Fisheries Society, 113:217-223.

Gale, W.F., and K.N. Mohr, Jr. 1978. Larval fish drift in a large river with a comparison of sampling methods. Transactions of the American Fisheries Society, 107(1): 46-55.

Gardner, B. 1985. Fisheries Biologist. Montana Department of Fish, Wildlife and Parks. Personal communication.

Gardner, W.M. and R.K. Berg. 1982. An analysis of instream flow requirements for selected fishes in the Wild and Scenic portion of the Missouri River. Montana Department of Fish, Wildlife and Parks. 111pp.

Geen, G., T. Northcote, G. Hartman, and C. Lindsey. 1966. Life histories of two species of catostomid fishes in Sixteenmile Lake, British Columbia, with particular reference to inlet stream spawning. Journal of Fisheries Research Board of Canada, 23: 1761-1788.

Gerlach, J.M. and A.W. Kahnle. 1981. Larval fish drift in a warmwater stream. In: Proceedings of the warmwater streams symposium. American Fisheries Society, Bethesda, Maryland. L.A. Krumholz editor.

Goodyear, C.P., 1977. Assessing the impact of power plant mortality on the compensatory reserve of fish populations. In: W. van Winkle (editor), Proc. Conf. Assessing the Effects of Power Plant Mortality on Fish Populations. Pergamon Press, New York, NY, 186-195pp.

Goodyear, C.P., 1978. Entrainment impact estimates using the equivalent adult approach. FWS/OBS - 78/65, Power Plant Project, Fish and Wildlife Service, U.S. Department of the Interior, Washington, D.C., 14pp.

Graham, P.J. and R.F. Penkal. 1978. Aquatic environmental analyses in the lower Yellowstone River, Montana. Montana Department of Fish, Wildlife and Parks. 102pp.

Helms, D. 1985. Research Biologist. Iowa conservation commission. Personal communication.

Horst, T.J., 1975. The assessment of impact due to entrainment of ichthyoplankton. In: S.B. Salie (Editor), Fisheries and Energy Production: a Symposium. Heath, Lexington, MA, 107-118pp.

Hubert, W.A., S.H. Anderson, P.D. Southall and J.H. Crance. 1984. Habitat suitability index models and instream flow suitability curves: paddlefish. U.S. Fish and Wildlife Service. FWS/OBS-82/10.80. 32 pp.

Hynes, H.B.N. 1970. The ecology of running waters. University of Toronto Press, Toronto, Canada. 555pp.

Hyra, R. 1978. Methods for assessing instream flows for recreation. Instream Flow Information Paper: No. 6. FWS/OBS - 78/34. 44pp.

Kallemyn, L.W. and J.F. Novotny. 1977. Fish and fish food organisms in various habitats of the Missouri River in South Dakota, Nebraska and Iowa. U.S. Fish and Wildlife Service, Office of Biological Services 77/25. 100pp.

Kozel, D.J. 1974. The utilization of select habitats by immature and adult fishes in the unchannelized Missouri River. MA Thesis, University of South Dakota, Vermillion. 74 pp.

Lund, R.E. 1985. MSUSTAT An interactive statistical analysis package. Research and Development Institute Inc. Montana State University, Bozeman, Montana. 146pp.

Marcy, B.C., Jr., V.R. Krantz, and R.P. Barr. 1980. Ecological and behavioral characteristics of fish eggs and young influencing their entrainment. Pages 29-74 in C.H. Hocutt and J.R. Stauffer, Jr., editors. Power Plants: effects on fish and shellfish behavior. Academic Press, New York, New York, U.S.A.

McMahon, T.E., and J.W. Terrell. 1982. Habitat suitability index models: Channel catfish. USDI Fish and Wildlife Service. FWS/OBS-82/10.2.29 pp.

Miller, M. 1985. Hydrogeologist. Montana Bureau of Mines and Geology. Personal communication.

Modde, T.A. 1985. Assistant Professor. Department of Fisheries and Wildlife Sciences, South Dakota State University. Personal communication.

Nelson, F.A. 1980. Guidelines for using the wetted perimeter (WEPT) computer program of the Montana Department of Fish, Wildlife and Parks. 23pp.

Rago, P.J., 1984. Production forgone: an alternative method for assessing the consequences of fish entrainment and impingement losses at power plants and other water intakes. Ecological modelling, 24: 79-111.

Scott, W.B. and E.J. Crossman. 1973. Freshwater fishes of Canada. Fisheries Research Board of Canada, Ottawa. 966pp.

Snyder, D.E. 1983. Fish eggs and larvae. Pages 165-197 in L.A. Nielson and D.L. Johnson, editors. Fisheries Techniques. American Fisheries Society, 1983. Southern Printing Company Incorporated, Blacksburg, Virginia.

Tarplee, W.H. Jr. and W.E. Partin. 1981. Spatial and temporal distributions of ichthyoplankton in the Neuse River, North Carolina, near a low dam and power plant intake. In: Proceedings of the warmwater streams symposium. American Fisheries Society, Bethesda, Maryland. L.A. Krumholz editor.

U.S. Congress. 1975a. Hearings on S. 1506, a bill to amend the wild and scenic rivers act, part 2 - Missouri River, Montana. U.S. Government Printing Office, Washington D.C., 444pp.

U.S. Congress. 1975b. Designating a segment of the Missouri River in the state of Montana as a component of the national wild and scenic rivers system. Senate Report No. 94-502. 16pp.

U.S.D.I. 1980. Stream evaluation map - 1980. State of Montana. Published by the U.S. Fish and Wildlife Service. Office of Biological Services, Denver, Colorado. Cooperating agency - Montana Department of Fish, Wildlife and Parks, Helena, Montana.

U.S. EPA. 1973. Reviewing environmental impact statements - power plant cooling systems, engineering aspects. Environmental Protection Technology Series EPA - 660/2-73-016. Corvallis, Oregon.

Willock, T.A. 1969. Distributional list of fishes in the Missouri River drainage of Canada. Journal of Fisheries Research Board of Canada, 26:1439-1449.

307/4