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LOWER YELLOWSTONE RIVER FISHERY STUDY

Final Report

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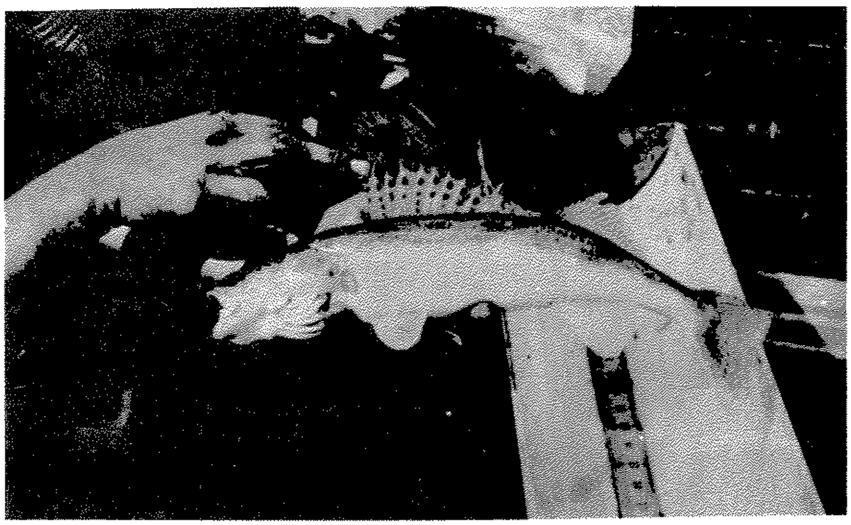

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BACKGROUND

National and international energy related events require serious energy conservation measures and a high degree of national energy self-sufficiency. Suggested as part of the solution to the energy problem is the utilization of the vast coal reserves of the western United States.

The Fort Union coal formation underlies much of eastern Montana. This formation contains an estimated 43 billion tons of economically recoverable coal in Montana (Matson 1974). The conversion of coal to more usable forms of energy requires significant quantities of water. The development of coal resources at mine sites for electric power generation, synthetic gas or liquid fuels will require diversion of water from the Yellowstone River and/or its tributaries and conveyance by aqueducts to the mine sites. Withdrawal of water from the Yellowstone River and tributaries may require storage and diversion structures affecting the present flow regimen and associated aquatic communities.

It is apparent that exploitation of eastern Montana coal can have far-reaching effects upon the Yellowstone and its tributaries. Basic data on the life history and distribution of important game, nongame and forage species of fish in the lower Yellowstone sufficient for complete analysis of the environmental impacts of these diversions and structures are lacking. This study was initiated in April of 1974 to provide such data.

OBJECTIVES

The objectives of this project are to collect basic inventory and life history data to develop better understandings of existing fish populations and habitats needed to sustain the species present. This information will be used for making decisions on water use and recommendations on diversion points, and for accurate preparation of environmental impact statements.

DESCRIPTION OF THE STUDY AREA

The study area encompassed the Yellowstone River from the mouth of the Bighorn River to its confluence with the Missouri River and is commonly referred to as the lower Yellowstone. The aquatic characteristics of the entire river are briefly described to place the lower river in the perspective of the entire system.

The Yellowstone River is free-flowing over its entire length, making it unique among the large rivers of the continental United States. The

Yellowstone originates in the northeast corner of Wyoming and flows northeasterly through Montana before joining the Missouri River near Cartwright, North Dakota. It has a total drainage area of approximately 70,400 square miles, 35,900 of which lie in Montana. Its length, from its headwaters in Wyoming to its confluence with the Missouri River in North Dakota, is approximately 678 miles, 550 of which are in Montana.

Major tributaries to the Yellowstone in Yellowstone Park include the Gardner and Lamar Rivers. In Montana, the only major south flowing tributary to the Yellowstone is the Shields River, near Livingston. Major north flowing tributaries to the Yellowstone include the Boulder, Stillwater, Clarks Fork of the Yellowstone, Bighorn, Tongue and Powder Rivers (Figure 1).

The Yellowstone is of great importance as a sport fishery and can be divided into three general zones related to fish distribution. From its headwaters in Wyoming to its mouth in North Dakota, the river changes from an alpine salmonid fishery to a diverse warm-water fishery. A longitudinal gradient profile of the Yellowstone is presented in Figure 2.

The upper Yellowstone, from Gardiner to Big Timber (111 miles), supports a cold water salmonid fishery of national significance and has been classified as a Blue Ribbon Trout Stream by the Montana Fish and Game Commission. The primary trout species are cutthroat, rainbow and brown trout. Large populations of mountain whitefish exist and longnose sucker are also abundant. The principal forage fish species is the mottled sculpin.

Stream gradients were calculated for the upper river from the mouth of Pine Creek to Big Timber. The average drop in elevation per river mile for this reach is 12.9 feet; however, individual gradients for short sections (2 to 6 miles long) within this area varied from 10.0 to 18.2 feet per mile (Table 1).

Flow regimens are monitored by U. S. Geological Survey gage stations at two locations on the main stem of the upper Yellowstone, Corwin Springs and immediately upstream from Livingston at Carter's Bridge. The average annual discharge at Corwin Springs for a 67 year period of record was 2.25 million acre-feet (MAF) (3,100 cubic feet per second, cfs). At Livingston, the average annual discharge (48 year period of record) is 2.70 MAF (3,700 cfs). The highest flow recorded at Livingston was 30,600 cfs (June 20, 1943), and lowest was 590 cfs (January 22, 1940). During the water year, October 1972 through September 1973, the maximum recorded flow was 21,000 cfs (June 10, 1973);

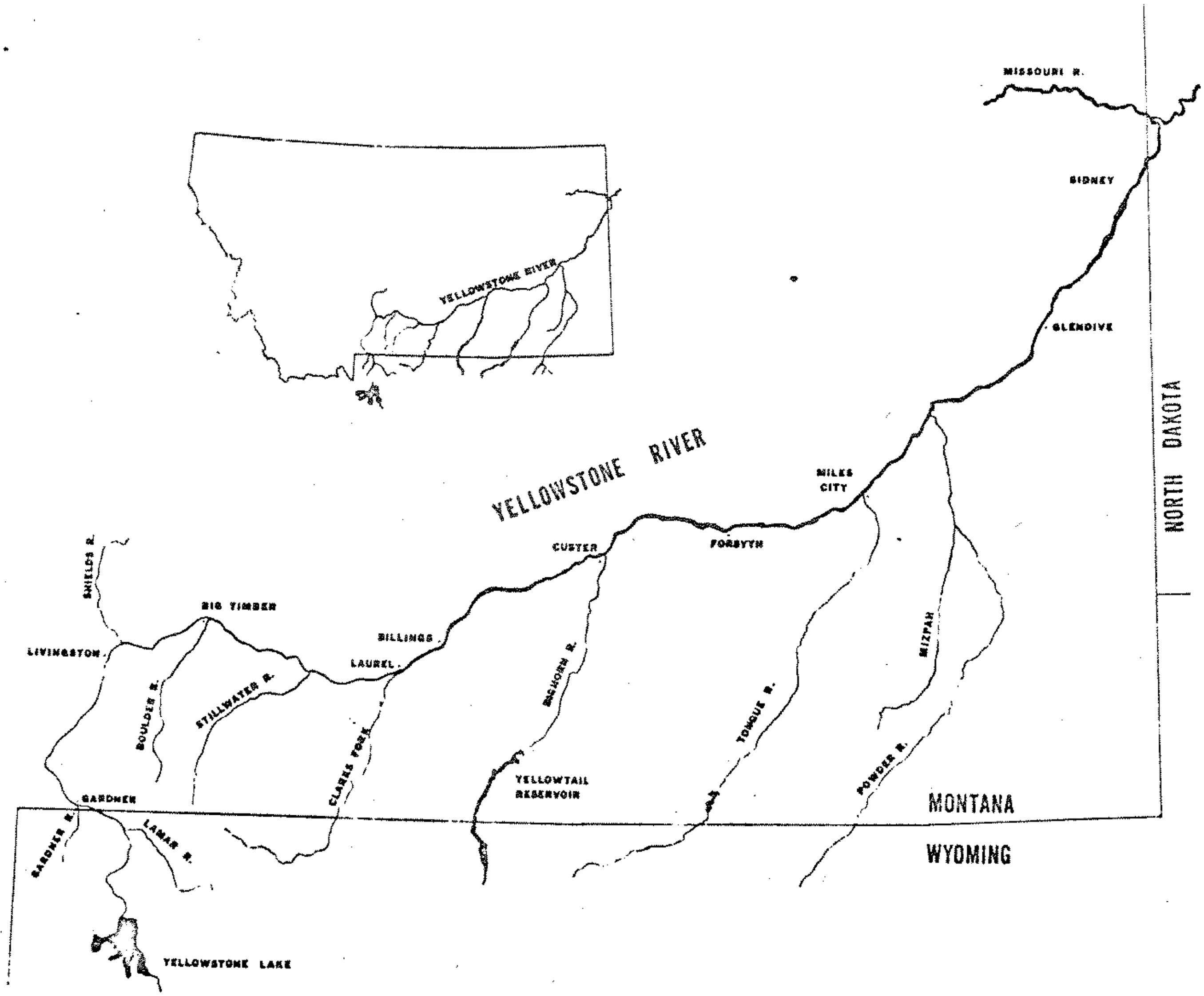


Figure 1. Yellowstone River drainage.

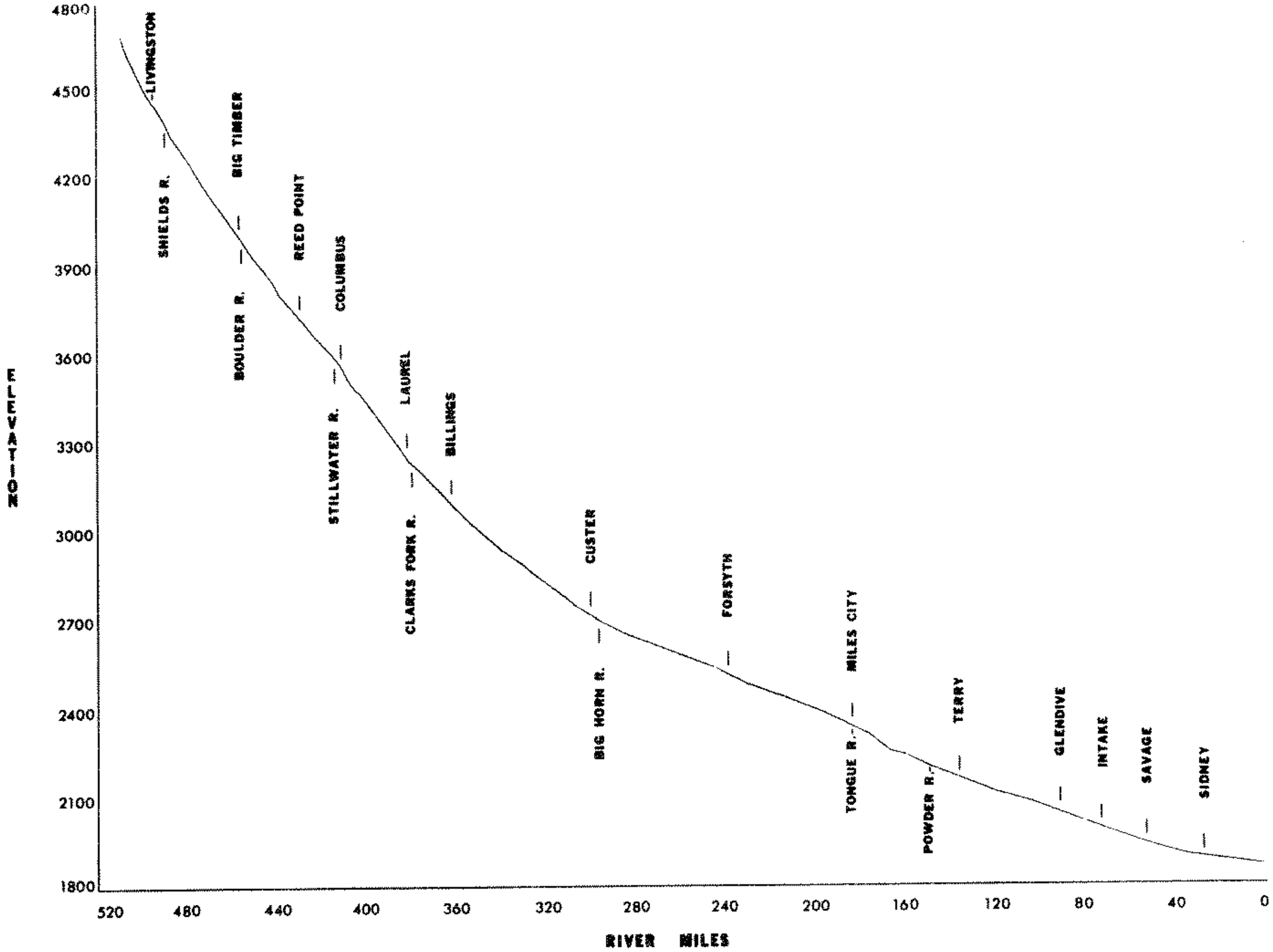


Figure 2. Longitudinal profile of the Yellowstone River from the mouth of Pine Creek to its confluence with the Missouri River.

Table 1. Stream gradients of the Yellowstone River from the mouth of Pine Creek to Big Timber.

River Mile	Elevation	Gradient (Ft/Mile)
509.4	4680	
507.1	4640	16.0
505.0	4600	18.2
501.2	4540	15.4
498.9	4500	16.7
494.4	4460	11.4
492.4	4420	12.5
489.5	4380	13.3
486.5	4340	12.9
483.2	4300	11.8
477.3	4240	10.0
474.6	4200	14.3
471.1	4160	11.1
465.6	4100	10.7
460.0	4040	10.3
456.6	4000	11.4

the minimum flow was 1,250 cfs on December 8, 1972 (USGS Water Resource Data for Montana 1973).

The middle Yellowstone, from Big Timber to the mouth of the Bighorn River (160 miles), is considered a transition zone between the primarily cold water environment of the upper river and the warm water environment of the lower river. In this area, both cold and warm water fishes are present, but information on fish populations is lacking.

The average river gradient for the middle Yellowstone is 8.1 feet per mile. Gradients for individual sections within this area varied from 11.4 to 5.1 feet per mile (Table 2).

The average annual discharge at Billings for a 45 year period of record was 4.97 MAF (6,862 cfs). The highest flow recorded was 66,100 cfs (June 16, 1967); the lowest flow recorded was 430 cfs (December 12, 1932). During the 1972 - 1973 water year, the maximum flow of 37,700 cfs was recorded on June 11, 1973, and minimum flow of 1,100 cfs on December 5, 1972 (USGS Water Resource Data for Montana 1973).

The lower Yellowstone extends from the mouth of the Bighorn River to its confluence with the Missouri River and is approximately 395 miles long. This area supports a diverse aquatic ecosystem containing a wide variety of species commonly known as warm water fishes. Important sport species found in the lower Yellowstone include: paddlefish, shovelnose

Table 2. Stream gradients of the Yellowstone River from Big Timber to the mouth of the Bighorn River.

River Mile	Elevation	Gradient (Ft/Mile)	River Mile	Elevation	Gradient (Ft/Mile)
456.6	4000	10.8	380.6	3240	7.3
449.2	3920	9.5	375.1	3200	8.0
447.1	3900	10.9	372.6	3180	8.3
441.6	3840	10.5	366.6	3130	7.9
437.8	3800	9.2	360.3	3080	7.4
429.1	3720	8.7	350.8	3010	6.7
426.8	3700	8.9	343.3	2960	6.8
422.3	3660	8.7	338.9	2930	5.3
415.4	3600	10.5	329.4	2880	6.9
411.6	3560	11.4	323.6	2840	5.7
408.1	3520	10.5	316.6	2800	5.3
404.3	3480	10.0	310.9	2770	5.3
402.3	3460	10.5	307.1	2750	5.1
398.5	3420	10.5	301.2	2720	5.3
394.7	3380	9.3	297.4	2700	6.3
386.1	3300	10.0	295.7	2690	
384.1	3280	11.4			

sturgeon, sauger, walleye, channel catfish, northern pike and burbot. In addition, large populations of nonsport species represent a lightly utilized but potentially valuable resource.

The average river gradient for the lower river is 2.8 feet per mile. Gradients for individual sections within this area varied from 1.0 foot per mile near Sidney to 5.7 feet per mile near Miles City (Table 3).

Flow regimens are monitored by the U. S. Geological Survey at Miles City and Sidney. The average annual discharge for a 46 year period of record at Miles City and a 61 year period at Sidney was 8.2 MAF (11,340 cfs) and 9.4 MAF (13,030 cfs) (USGS Water Resource Data for Montana 1973). The mean annual discharge at Sidney, adjusted to the 1970 level of water usage, is 8.8 MAF (12,146 cfs) (Northern Great Plains Resource Program, 1974).

The highest flow recorded at Sidney was 159,000 cfs (June 2, 1921) and lowest was 470 cfs on May 17, 1961. During the water year, October 1972 through September 1973, the maximum recorded flow was 47,700 cfs (June 13, 1973). Minimum flow was 3,200 cfs on December 10, 1972 (USGS Water Resource Data for Montana, 1973).

Fifty fish species, representing thirteen families, have been recorded for the Yellowstone River in Montana (Table 4). The probable distribution of 33 of the 50 species is illustrated in Figure 3.

There is an increase in the number of species progressing downstream on the Yellowstone. In Yellowstone National Park, above Tower Junction, the cutthroat is the only trout species present. Eleven fish species (five families) have been recorded for the upper Yellowstone River in Montana; however, only six species (four families) are considered common or abundant. The middle river contains approximately 20 fish species representing eight families; however, sampling in this area has been very limited. The lower Yellowstone is the most diverse, with 46 species (12 familes) recorded.

FINDINGS

Emphasis during the study was: 1) life history studies of important sport species, 2) equipment and sampling technique adaption development, and 3) predicting impacts of possible altered flow regimes on habitat of important sport species. The majority of work was directed toward life history studies on several important sport species including sauger, walleye, channel catfish, burbot and shovelnose sturgeon. Data on other species were collected coincidental to these studies; forage fish were sampled and identified. Predicting impacts of possible altered flow regimes (resulting from water development projects) on important sport species is dependent on a knowledge of the life histories of these

Table 3. Stream gradients of the Yellowstone River from the mouth of the Bighorn River to its confluence with the Missouri River.

River Mile	Elevation	Gradient (Ft/Mile)	River Mile	Elevation	Gradient (Ft/Mile)
295.6	2690	3.3	160.2	2240	3.8
292.7	2680	3.8	154.9	2220	3.6
287.5	2660	3.5	149.5	2200	3.0
281.9	2640	3.0	122.6	2120	2.5
275.3	2620	2.4	114.7	2100	2.3
267.3	2600	2.7	106.1	2080	2.4
260.1	2580	3.5	97.5	2060	3.0
251.6	2550	2.9	90.9	2040	3.2
244.8	2530	3.2	87.9	2030	2.7
238.6	2510	3.1	84.1	2020	2.7
228.9	2480	3.1	80.4	2010	3.0
222.5	2460	2.7	77.1	2000	2.8
215.2	2440	3.1	73.5	1990	2.7
208.8	2420	2.9	69.8	1980	2.4
202.2	2400	3.0	65.7	1970	2.4
195.7	2380	3.2	61.6	1960	2.7
189.5	2360	4.5	57.9	1950	3.1
187.4	2350	3.3	54.7	1940	2.6
184.5	2340	3.8	50.9	1930	2.2
176.5	2310	4.7	37.4	1900	1.0
174.4	2300	5.7	27.7	1890	1.3
170.8	2280	4.0	20.2	1880	
165.9	2260	3.5			

Table 4. Fish species recorded for the Yellowstone River (family, scientific and common names).

ACIPENSERIDAE (Sturgeon Family)	
Scaphirhynchus albus	Pallid sturgeon
Scaphirhynchus platorynchus	Shovelnose sturgeon
POLYODONTIDAE (Paddlefish Family)	
Polyodon spathula	Paddlefish
HIODONTIDAE (Mooneye Family)	
Hiodon alosoides	Goldeye
SALMONIDAE (Trout Family)	
Prosopium williamsoni	Mountain whitefish
Salmo clarki	Cutthroat trout
Salmo gairdneri	Rainbow trout
Salmo trutta	Brown trout
Salvelinus fontinalis	Brook trout
ESOCIDAE (Pike Family)	
Esox lucius	Northern pike
CYPRINIDAE (Minnow Family)	
Cyprinus carpio	Carp
Carassius auratus	Goldfish
Notemigonus crysoleucas	Golden shiner
Semotilus margarita	Pearl dace
Semolitus atromaculatus	Creek chub
Hybopsis gracilis	Flathead chub
Hybopsis gelida	Sturgeon chub
Couesius plumbeus	Lake chub
Notropis atherinoides	Emerald shiner
Notropis stramineus	Sand Shiner
Hybognathus hankinsoni	Brassy minnow
Hybognathus placitus	Plains minnow
Hybognathus nuchalis	Silvery minnow
Pimephales promelas	Fathead minnow
Rhinichthys cataractae	Longnose dace
CATOSTOMIDAE (Sucker Family)	
Carpoides carpio	River carpsucker
Cycleptus elongatus	Blue sucker
Ictiobus bubalus	Smallmouth buffalo
Ictiobus cyprinellus	Bigmouth buffalo
Moxostoma macrolepidotum	Shorthead redhorse
Catostomus catostomus	Longnose sucker
Catostomus commersoni	White sucker
Catostomus platyrhynchus	Mountain sucker
ICTALURIDAE (Catfish Family)	
Ictalurus melas	Black bullhead
Ictalurus punctatus	Channel catfish
Noturus flavus	Stonecat
GADIDAE (Codfish Family)	
Lota lota	Burbot
CENTRARCHIDAE (Sunfish Family)	
Ambloplites rupestris	Rock bass
Lepomis cyanellus	Green sunfish
Lepomis gibbosus	Pumpkinseed
Lepomis macrochirus	Bluegill
Micropterus dolomieui	Smallmouth bass
Micropterus salmoides	Largemouth bass
Pomoxis annularis	White crappie
Pomoxis nigromaculatus	Black crappie
PERCIDAE (Perch Family)	
Perca flavescens	Yellow perch
Stizostedion canadense	Sauger
Stizostedion vitreum	Walleye
SCIAENIDAE (Drum Family)	
Aplodinotus grunniens	Freshwater drum
COTTIDAE (Sculpin Family)	
Cottus bairdi	Mottled sculpin

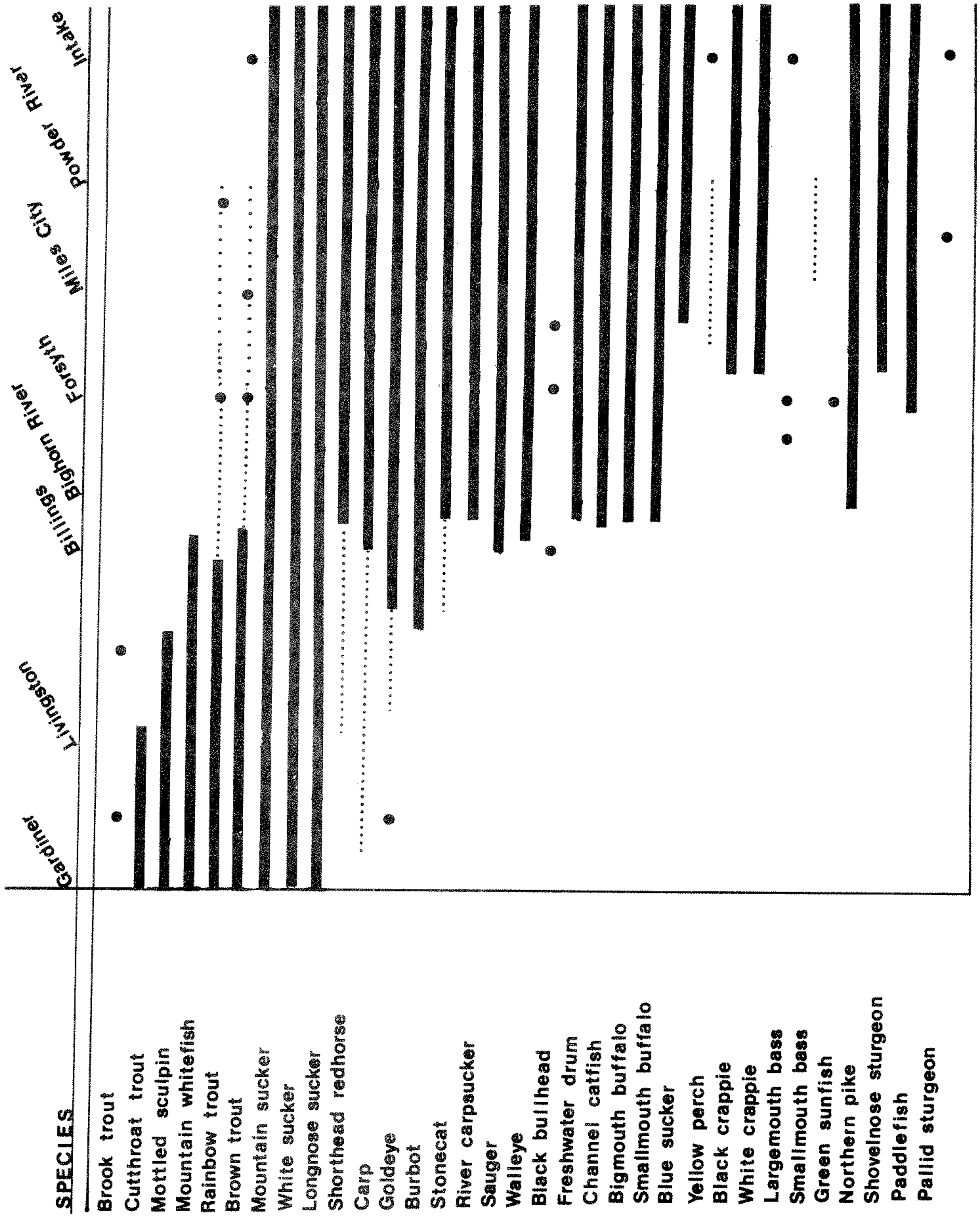


Figure 3. Longitudinal distributions of some fishes of the Yellowstone River of Montana.

Dotted lines denote occasional occurrence. Solid line indicates reproductive success in the area. Large dots indicate occurrence of a few individuals.

species. Once this information is obtained, changes in the physical habitat can be related to impacts on a particular life history component of a species.

Equipment and Sampling Technique Adaptation

The relatively high current velocities, turbid water conditions, and diverse fish fauna of the lower Yellowstone required considerable equipment and sampling technique adaptations. Much time during the study period was expended to evaluate different sampling techniques. Following is a discussion of the fish sampling methods employed during the study.

Electrofishing

A 17 ft. x 5 ft. flat bottom aluminum boat, powered by an 85 HP jet outboard, was chosen for the electrofishing operations on the lower river. The electrofishing unit included a variety of fixed positive and negative electrode arrangements suspended from fiberglass booms fastened to the front of the boat. The power source was a 4500 watt AC generator, ample for the electrofishing apparatus and supplemental lighting equipment for night shocking. Voltage and amperage regulation, from the power source to the water, was through a Coffelt Variable Voltage Pulsator model VVP-10. This electrofishing unit produced output voltages of 0 to 300 volts with AC, DC, or pulsed DC current at 0 to 25 amps. The capacity of the unit was 10,000 watts.

The current type, voltage, amperage and electrode arrangement for efficient capture of fish used in the lower river depended upon the fish species being sought, water temperature, conductivity, turbidity, depth of water and fish distribution.

An AC boom electrofishing unit was used on shallow (less than 6 feet) portions of the main channel, larger side channels and backwater areas of the lower Yellowstone. This unit was not effective in deep pool areas unless fish were schooling near the surface. The AC electrode system was composed of four (6 foot) lead core copper grounding rods suspended vertically from a fiberglass cross boom.

When using an AC system, the primary response is the simple immobilization of fish (electrotetanus). In clear water and at depths of less than 5 feet, most fish stunned can be netted; however, during extremely turbid water conditions, many stunned fish are not seen and consequently not netted.

In clear water, and using AC current at 6 to 10 amps and 140 to 160 volts, this unit was effective in capturing sauger, walleye, crappie, drum, shorthead redhorse, longnose sucker, white sucker, blue sucker, carp, goldeye, river carpsucker, bigmouth buffalo, smallmouth buffalo and paddlefish. It was effective on channel catfish only in clear shallow water. It was not effective for capturing northern pike, burbot or shovelnose sturgeon.

Additional experimentation with AC systems will involve alternate polarity and multiple pair electrode array systems decribed by Novotony and Priegel (1974).

With a DC or pulsed DC current system, fish (within the electrical field) respond by swimming toward the anode (electrotaxis). When the anode is near the surface, the fish swim toward the surface, where they can be seen and netted. This is valuable under turbid water conditions, where visibility is limited. A pulsed DC current was used because this combined, to a degree, the desired forced swimming response of DC with the larger electrical field of AC (Novotony and Priegel, 1974).

All of the fish species, listed as susceptible to AC electrofishing, exhibited good responses to pulsed DC current. Burbot and shovelnose sturgeon also responded to the DC system.

A mobile electrode DC unit (Vincent 1971) was ineffective in the lower Yellowstone, but was used to sample sauger in the Tongue River.

Three types of DC boom electrode systems were constructed during the study period. The first was used during the spring of 1974, and consisted of 2 positive electrodes made of 2 (four foot) copper grounding rods bent into a bell shape.

The positive electrodes were suspended by chain from fiber glass poles approximately three feet ahead of the bow. Four negative electrodes (6 foot copper grounding rods) were suspended from the booms, ahead of the positives, approximately 10 feet in front of the bow. This unit was effective collecting a number of species, but was difficult to maneuver due to excessive weight in the front of the boat.

A second DC boom electrode system was used during the spring of 1975 in an attempt to overcome chronic turbidity problems. The electrode system consisted of two spherical positive electrodes, 15 inches in diameter, suspended from the end of the booms, approximately 8 feet apart. The negative system was composed of two (9 foot strands) 3/8 inch braided steel wire trailing from the stern. Operating voltages ranged between 160 to 230 and amperage between 6 to 18.

A third DC boom electrode system was used during the fall of 1975 and spring of 1976. This system was similar to the DC system above; however, the negative 3/8 inch cable electrode was replaced by ten (4 foot by 3/4 inch) flexible armored cables, five suspended from each side of the boat (Novotony and Priegle,1974). Although operating voltages and amperage were similar to those of the other systems, most species appeared to respond better.

DC boom electrofishing unit found to be most effective in collecting a wide variety of species.

Gill Netting

Gill netting, although limited in use to specific habitat types, was a valuable sampling tool on the lower river. Two methods of gill netting were utilized: stationary and drift.

Stationary (dead set) gill nets were set in backwater areas, below the downstream end of gravel bars in midstream, and in slack or slow current areas of the main channel. Gill nets used for this purpose were standard experimental sinking nets, 125 feet in length, 6 feet deep, with a graduated 3/4 to 2 inch square unit mesh. Dead set gill nets were effective for capturing a wide variety of fish species, but their usefulness for gathering complete distribution data was limited, because they could only sample areas with little or no current.

Large mesh (2½ to 3½ inch square) sinking gill nets were used on the lower Tongue and Yellowstone Rivers. These nets were 8 feet deep and varied in length from 75 to 150 feet. They were drifted perpendicular to the current in main channel areas which were free from snags. The length of the drifts varied from 100 to 500 yards, depending on channel configuration, snags, etc.

Drifting large mesh gill nets proved to be an effective method for capturing shovelnose sturgeon in the lower Tongue and Yellowstone Rivers. This method was quite selective for shovelnose, 50 to 100 percent of the catch in individual drifts. The size of shovelnose captured in the large mesh nets varied from 1.5 to 15.5 pounds. Although there was selection for larger fish using this technique, the sharp and angular nature of the five rows of bony scutes found on the shovelnose caused many of the smaller individuals to also become entangled.

Several other species were also captured using this technique. Channel catfish and blue suckers were taken from main channel areas of the Yellowstone and lower Tongue. A single pallid sturgeon was taken below Intake. Eight paddlefish "hits" were recorded on two 15 minute drifts on the Yellowstone below Intake; however, only one was captured.

Hoop Nets

Hoop nets, 36 and 24 inches in diameter, were used to collect channel catfish. These nets were baited with rotten cheese and set in a variety of areas in the lower Yellowstone River, but were ineffective. The use of hoop nets for catching channel catfish is usually highly successful and is the primary tool of commercial catfish fishermen in large rivers. Excellent success has been reported by others in collecting channel catfish with this type of net baited with cheese (Wallace personal communication). Our failure to use hoop nets effectively in the Yellowstone may be due to high current velocities, which sometimes collapse the nets and inexperience with this particular method.

Seines

Two seines were used during the study, a 30 ft. x 6 ft. x 1/4 inch mesh and a 150 ft. x 8 ft. x 1/4 inch mesh loose hung with a bag. The smaller seine was used in areas not feasible for the large one. Primarily, the large seine was used in large backwaters and for main channel beach seining. Both were used to collect forage species and young of the year sport species.

Setlines and Angling

Setlines and angling (using minnow bait) were primarily employed to collect burbot during 1973 and 1974. This was a highly successful collection method for burbot in the early spring. Setlines were also used to collect channel catfish; however, the ratio of man hours to catch rate did not justify continued use of this technique.

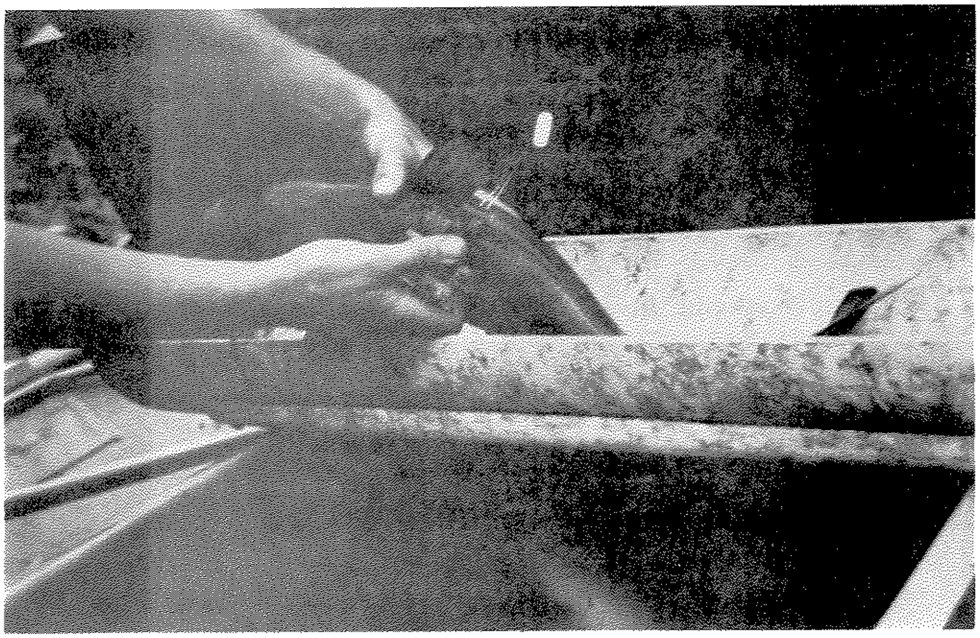
Fish Tags

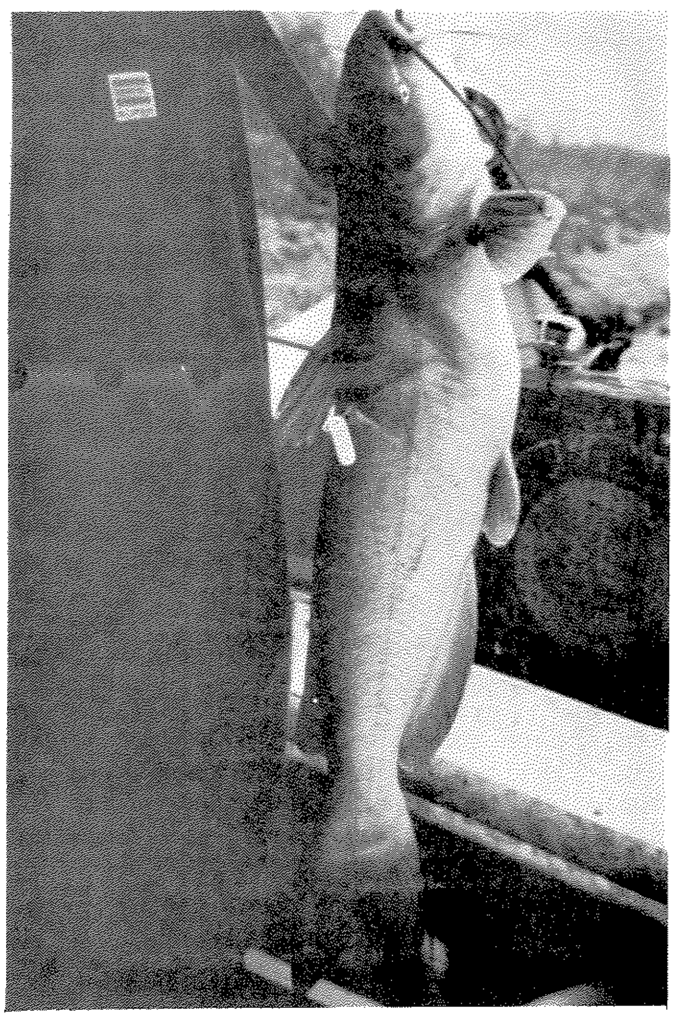
A variety of individually numbered tags were experimentally attached to several fish species during the past year. The selection of a specific type of tag for each species involved an analysis of the retention of the tag, the mortality caused by the tag or tagging procedure, and any behavioral aberrations caused by the tag or its application.

Numbered fish tags are valuable for monitoring movement patterns of individual fish and establish home ranges. Fish marked during spawning migrations or at spawning areas and recaptured later provided information on distances traveled to reach the spawning site and the importance of specific spawning areas to downstream reaches of the Yellowstone. This information becomes important when evaluating possible diversion structures which might present barriers to upstream migrations of fish. Tagged fish recaptured on spawning sites in subsequent years will provide data on homing to specific sites and periodicity of the spawning cycle of certain species. Recapture of individually marked fish also provides a check on certain aging techniques and an indication of angler rates.

Shovelnose sturgeon were tagged using individually numbered number 3 monel metal tags clipped to the pectoral fin near the body (Schmulbach 1974). This tag was retained on the fish but awkward to attach to larger fish. Scar tissue grew over the tag, at times covering it completely. Numbered Floy anchor (T) tags were inserted directly behind the dorsal fin; however, tag retention and mortality by this method was questionable (the caudal peduncle area of the shovelnose is quite small and the possibility exists of puncturing the notochord with the tagging needle unless extreme care is exercised). Floy anchor tags were also inserted through the pectoral girdle dorsal to the fin. Tag loss by this method was also a serious problem (Helms 1974). Aluminum poultry bands, which encircled the caudal peduncle, caused serious irritation. A tag with good retention, that does not injure sturgeon, has not been found.

Channel catfish were initially tagged with Floy anchor tags inserted near the base of the dorsal fin. Recaptured fish indicated a significant tag loss resulting from this method. The tagging method described by Pelgen and McCammon (1955), involves fastening a round numbered plastic tag to the body, posterior to the dorsal fin, with 0.032 inch diameter stainless steel wires. Preliminary tagging studies in Nebraska (Bliss personal communication) indicated little chance of tag loss and injury to the fish from this method.





Sauger, walleye, northern pike, blue sucker, bigmouth buffalo, smallmouth buffalo and burbot were tagged with the Floy anchor tags anchored near the base of the dorsal fin. No tag losses were observed on sauger and walleye; this method will continue to be employed for future studies on these two species. Insufficient recaptures were obtained for an analysis of tag retention on the other species mentioned above.

LIFE HISTORY STUDIES

Shovelnose Sturgeon

The shovelnose sturgeon is common in portions of the Mississippi, Missouri, Ohio and Yellowstone River drainages. The Yellowstone, however, is the only major river which has not been significantly altered by dam construction and/or channelization, offering a rare opportunity to study this species in a largely unregulated river system. (The closely related pallid sturgeon is found throughout the larger streams and reservoirs of the Mississippi-Missouri River system, but occurs only rarely (Brown 1971). In the Yellowstone River, the pallid sturgeon is also rare, occasionally taken at the mouth of the Tongue River and below the Intake diversion structure.)

The shovelnose sturgeon is a popular sport species in the lower Yellowstone. It was classified as a game fish by the 1975 Montana Legislature, but seasons and bag limits have not been set. There is no commercial fishery for the shovelnose on the Yellowstone, but elsewhere in its range it is a valuable commercial species. Shovelnose are commonly taken by anglers below the low head irrigation diversions at Forsyth and Intake, in the Tongue and Powder Rivers, and near their mouths in the Yellowstone. The Tongue and Powder River fishery exists during the spring high water period.

Investigations into the distribution and life history of the shovelnose sturgeon were initiated in April of 1974. First year efforts concentrated on sampling the spawning runs in the Tongue and Powder rivers, while later sampling was confined to the main stem Yellowstone. Subsequent monitoring of the shovelnose sturgeon runs up the Tongue and Powder rivers was conducted under separate projects.

Distribution in Yellowstone River

Shovelnose sturgeon are common in the Yellowstone River from the Cartersville irrigation diversion at Forsyth (river mile 237.4) downstream to its confluence with the Missouri River (river mile 0). Intensive sampling, during April and May 1974, upstream from the Cartersville diversion failed to produce any shovelnose. Sampling methods employed included seining, gill netting and electrofishing. The same techniques used below the Cartersville diversion, during the same time period, resulted in a catch of 38 shovelnose. Also, many more were observed but not netted during the electrofishing sampling. It appears that the Cartersville diversion represents the upstream limit of shovelnose distribution in the Yellowstone River and may represent a barrier to upstream shovelnose sturgeon migration. Several longtime residents of the area reported shovelnose to be common in the Yellowstone above Forsyth before the diversion dam was constructed.

The construction of the Cartersville diversion dam probably eliminated the shovelnose from areas farther upstream. Christenson (1975) in Wisconsin found shovelnose in tributaries to the Mississippi only upstream as far as the first dam. Historically, however, their presence was suspected in upstream areas before construction of the dams (Priegel - personal communication).

Spawning

The shovelnose is reported to spawn from May to July (Brown 1971); however, its actual spawning habits are largely unknown. During the spring of 1974, a portion of a spawning run from the Yellowstone into the lower 20 miles of the Tongue River was monitored. Between April 24 and July 8, 1974, 427 shovelnose were captured in the lower Tongue. Four hundred twenty were tagged and released for future studies to determine migration patterns, spawning periodicity, and degree of homing. Although the first sturgeon was captured on April 24, a sizable number of fish did not enter the Tongue until May 9. The period from May 13 through May 23 was characterized by low catch rates and corresponded to a drop in water temperature due to weather conditions (Figure 4). During the last week in May, water temperatures and catch rate again increased. The final sampling occurred on July 8, and resulted in a catch of 20 shovelnose.

Exact spawning times and locations were not determined during this sampling; however, ripe male shovelnose were captured from May 29 through the end of the sampling period. One ripe, partially spent, female was captured on June 4. The relationship between the shovelnose spawning run and the temperature and flow regimens of the lower Tongue during 1974 are presented in Figures 4 and 5.

During 1975 and 1976, the Tongue River shovelnose sturgeon run was monitored under the Tongue River and Tongue River Reservoir Fisheries Study. One is referred to Elser, McFarland and Schwehr (1977) for a detailed analyses of the shovelnose migration in the Tongue River.

Limited sampling during the spring of 1975 indicated the possible presence of a shovelnose sturgeon spawning migration into the lower reaches of the Powder River. Time limitations prevented an adequate assessment of the run. Subsequent investigations under a project entitled "Powder River Aquatic Ecology Project" confirmed the presence of a shovelnose run up the Powder and monitored it intensively. For additional information on the Powder River study, refer to Rehwinkel, Gorges and Wells (1976).

Length and Weight Comparisons

The average fork length of 427 shovelnose captured during the 1974 Tongue sampling was 30.2 inches and ranged from 20.9 to 40.1 inches. The average weight of these fish was 5.35 pounds and ranged from 2.10 to 15.5 pounds. Twenty-six percent of the total number of fish captured weighed 6 pounds or more, 11 percent 8 pounds or more, and 5 percent 10 pounds or more (Figure 6).

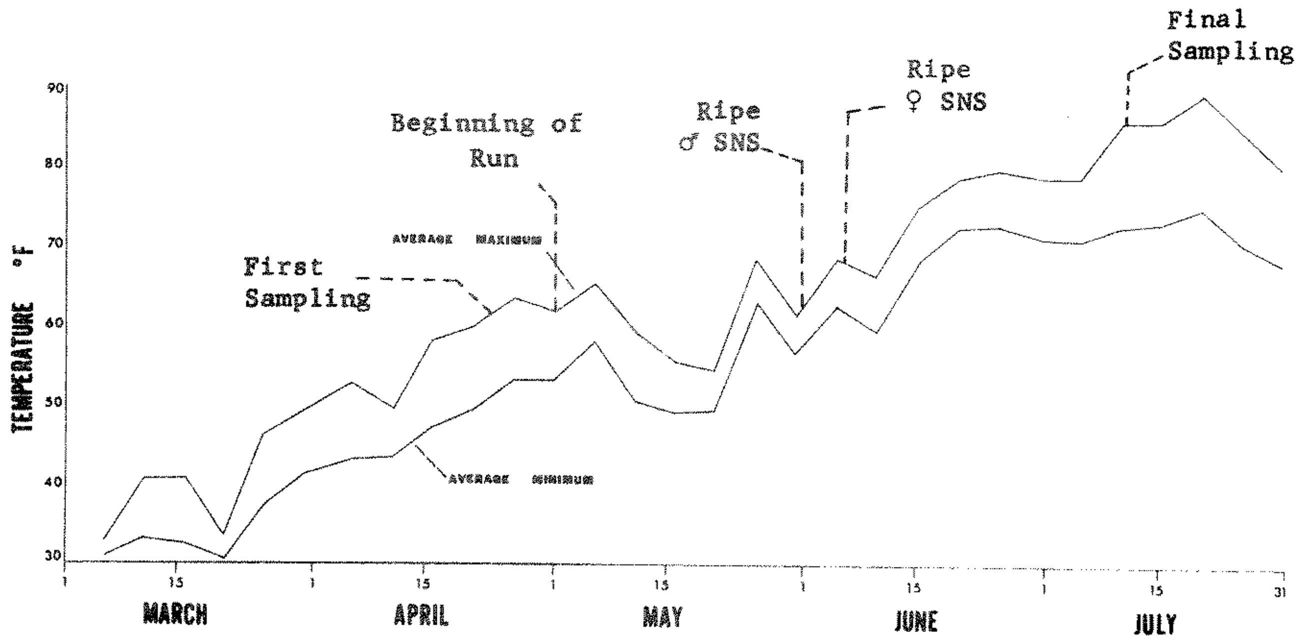


Figure 4. Relationship of shovelnose sturgeon (SNS) spawning run and the average 5-day maximum-minimum temperature regimen of the lower Tongue River during spring and summer 1974.

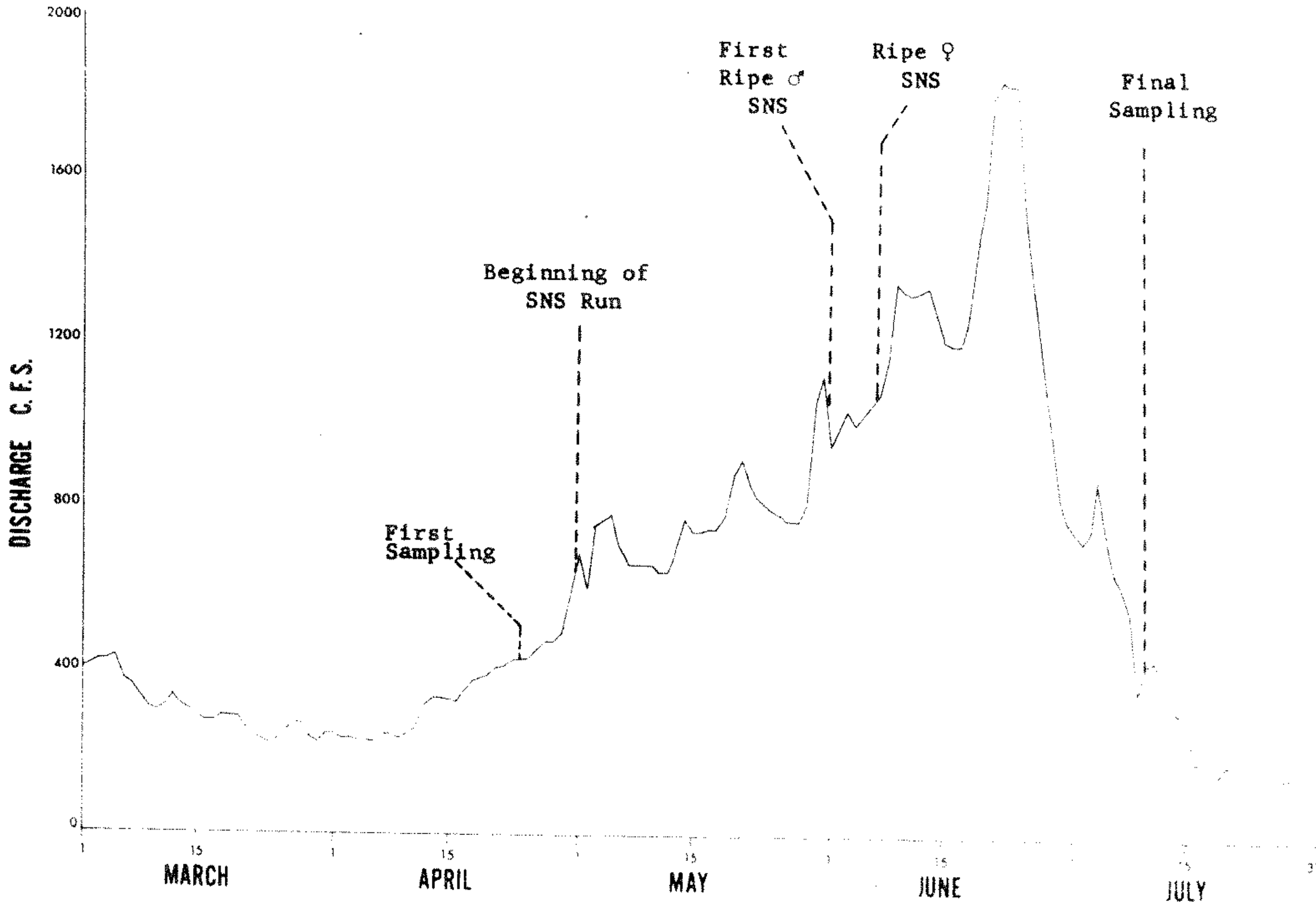


Figure 5. Relationship between shovelnose sturgeon (SNS) spawning run and discharge of the Tongue River during spring and summer 1974.

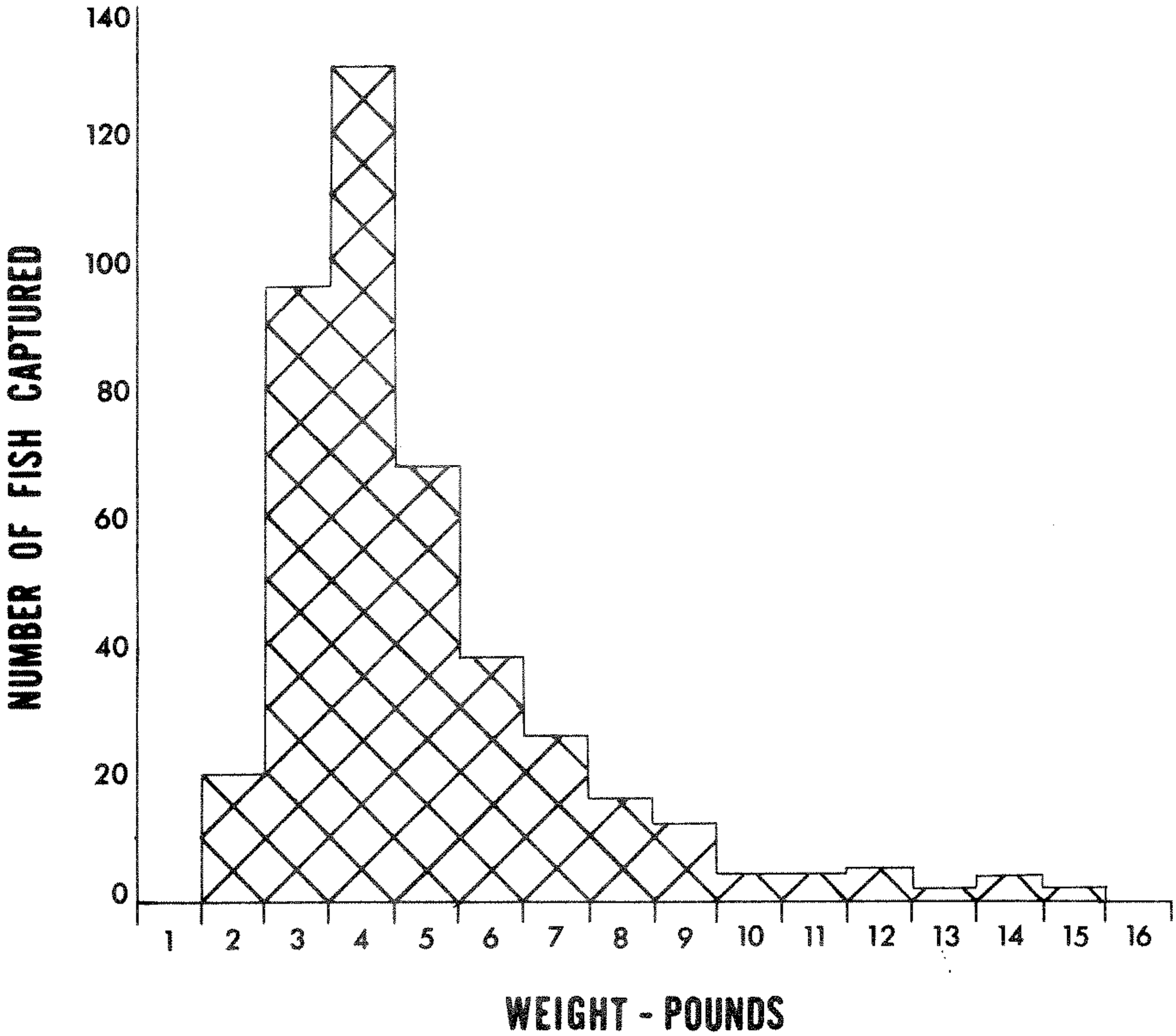


Figure 6. Weight - frequency of 427 shovelnose sturgeon captured in the lower Tongue River from April 24 to July 8, 1974.

Lengths and weights for the 1975 shovelnose run in the Tongue River were similar to 1974. The average weight for 1975 was 5.26 pounds and the average length was 29.4 inches (Elser and McFarland 1975). The shovelnose run in the Powder River during 1976 also exhibited a similar average length (30.0 inches) and weight (5.33 pounds) (Rehwinkel, Gorges and Wells 1976).

These fish were significantly larger than shovelnose reported elsewhere in the Missouri-Mississippi River drainage (verification of identification of larger specimens by Dr. W. Gould, Assistant Leader, Cooperative Fisheries Unit, Montana State University). Of 4,000 sturgeon examined from the lower Missouri River, the average size was approximately 1 pound, while fish over 4 pounds were rare (J.E. Schmulback, personal communication). On the Mississippi River, bordering Iowa, Helms (1974) reported that 60 percent of 4,204 commercially harvested shovelnose weighed between 1 to 2 pounds. The record 12 pound shovelnose for Iowa came from the Des Moines River (D. Helms, personal communication). The size difference between Mississippi and Missouri River shovelnose is not directly comparable. The Tongue River sample came from a suspected spawning run, and a larger average size would be expected for mature adult fish than from samples taken randomly from the entire population. Nevertheless, the number of fish larger than the maximum size reported for other areas appears significant.

Limited shovelnose sturgeon sampling was conducted during May 1974 in the Yellowstone below the Cartersville diversion at Forsyth (river mile 237.0) and below the Intake diversion structure (river mile 71.1). The average fork length of 32 sturgeon captured at Forsyth was 32.1 inches and varied from 27.6 to 36.1 inches. The average weight was 6.20 pounds and ranged from 3.86 to 9.65 pounds. By contrast, a sample of 16 shovelnose collected below Intake, during the same time period, averaged 25.2 inches in length and 2.19 pounds in weight. Weights for individual fish ranged from 1.14 to 3.10 pounds. Samples from both locations were taken by drifting graduated 2½ to 3½ inch square measure gill nets.

Shovelnose sturgeon sampling during May and early June of 1975 below Intake (3 mile section) was done by electrofishing with pulsed DC current. One hundred and two shovelnose were captured in 5 days of electrofishing. The average fork length and weight of fish from this sampling period was 20.0 inches and 1.42 pounds. Fork lengths of individual fish ranged from 11.3 to 32.1 inches and weights from 0.21 to 6.00 pounds. Of this sample, 28.4 percent of the shovelnose were less than 0.50 pounds, while 56.9 percent were less than 1.0 pound. Electrofishing with pulsed DC current is apparently a less selective method than drifting large mesh gill nets for sampling the shovelnose population.

Although the same time period was involved and similar habitat types were sampled, electrofishing with pulsed DC current at Miles City and Forsyth failed to produce shovelnose less than 1.35 pounds. This was in contrast to the section below the Intake diversion where shovelnose less than 1.0 pound were abundant and easily captured with pulsed DC current. Subsequent intensive sampling at Forsyth and Miles City has also failed to capture small shovelnose sturgeon (less than 1.0 pound). The relative ease with which small shovelnose are taken below Intake is in sharp contrast to their absence in the upstream sampling sites and suggests a significantly greater abundance of small shovenose in downstream areas.

Sauger and Walleye

Sauger and walleye are two of the more important sportfish in the lower Yellowstone River. Fishermen commonly refer to these two similar species as sand pike and pike. The most popular and productive areas for sauger and walleye angling are below low head irrigation diversion structures in the lower river (the Cartersville diversion at Forsyth and the Intake diversion below Glendive). Other popular sites are at the mouths and lower reaches of tributaries such as the Bighorn and Tongue Rivers.

The sauger is native to Montana and is found in both the Yellowstone and Missouri River drainages. It was first reported in Montana by Lewis and Clark (Coues 1893). It is common in the Missouri below Great Falls and the Yellowstone below Billings (Brown 1971). The walleye is not native to Montana, but has been widely introduced. It is less common than the sauger in the lower Yellowstone, but probably has a distribution similar to that of the sauger.

Prior to this study, no information was available on the sauger and walleye fishery or the life history aspects of the two species in the Yellowstone. There is also a scarcity of relevant literature pertaining to sauger and walleye in lotic environments. Morris (1964) felt the lack of such may be due to the difficulties of sampling large flowing waters, and the relatively low population densities which may occur in such environments.

Beginning in the fall of 1973 and continuing through the spring of 1976, studies were conducted to obtain information on distribution, abundance and life history of sauger and walleye in the lower Yellowstone River. Attempts were also made to define physical features of the river necessary to sustain existing sauger and walleye populations.

Four methods were used to collect sauger and walleye for these studies. Gill nets were used primarily to define distribution of sauger and walleye during September through November 1973 . AC electrofishing was used during the spring of 1974, and pulsed DC current was used during 1975 and the spring of 1976. A 150' x 8' x 1/4" mesh bag seine was used to collect young of the year and adult sauger and walleye over spawning areas in the spring of 1976.

Gill Net Survey Sauger and Walleye Distribution

Gill nets were used in the fall of 1973 in an attempt to define sauger and walleye distribution. From September through November, five areas of the lower Yellowstone were sampled with 125 foot experimental gill nets: Myers (river mile 284.0), Forsyth (river mile 238.0), Miles City (river mile 185.0), Terry (river mile 138.0) and Intake (river mile 71.1). One hundred seventy one sauger were taken with 89 overnight sets (18 hours) at these locations, averaging 1.92 sauger per net set. Catch rates ranged from 1.13 at Myers, to 3.83 at Terry (Table 5). Average size of these sauger was comparable to those reported by Posewitz (1963) for the Missouri River and tributaries from Fort Peck Reservoir to Morony Dam.

Only four walleye were taken during the 1973 fall gill net survey (2 at Myers and 1 at Terry and Intake).

Table 5. Catch rate and size of sauger taken in gill nets from five areas of the lower Yellowstone River during the fall (September to November) 1973.

	Myers (15) 1/	Forsyth (24)	Miles City (33)	Terry (6)	Intake (11)
Number of Sauger Per Net	1.13	2.04	1.45	3.83	3.09
Weight					
Average	1.0	1.3	0.7	0.7	0.8
Range	0.7-1.4	0.4-3.8	0.2-3.8	0.2-2.5	0.1-3.2
Length					
Average	14.9	15.4	13.0	12.8	13.3
Range	13.2-17.2	10.3-21.4	8.1-19.7	9.0-19.4	7.9-21.0

1/ Numbers in parenthesis equal number of net sets.

Population Numbers

During April and May 1974, a 1 mile section of the Yellowstone River below the Cartersville diversion at Forsyth was sampled by electrofishing to: 1) obtain a sauger population estimate, 2) define spawning periods and locate spawning areas, and 3) tag fish to study possible movements. Although other species were observed, only sport species and drum were collected during this sampling. Four hundred thirty fish, including 301 sauger and 13 walleye were captured in this section (Table 6).

Two hundred ninety five sauger and 13 walleye were tagged and released. Nineteen sauger (6.4 percent) were recaptured by electrofishing (Table 7). No walleye were recaptured.

An estimated (Schnabel estimator) 2,024 sauger were present in the section during the sampling period. Confidence intervals (80 percent) were 1,564 to 2,867 (Chapman and Overton 1966, Ricker 1975).

Certain assumptions required for the use of the Schnabel estimator might have been met (Chapman and Overton 1966). The sauger estimate was made based upon what was thought to be a spawning run. Spawning runs of sauger and walleye in rivers have been reported by a number of workers,

Table 6. Species composition, number and size of electrofishing catch from the Cartersville study section, April and May 1974.

	Number	Percent Total	Average Length	Range	Average Weight	
Sauger	301	70	15.4	(6.6-26.8)	1.2	(0.1-6.5)*
Walleye	13	3	19.8	(18.6-23.0)	2.8	(2.0-4.3)
Channel catfish	42	10	19.7	(13.6-29.0)	3.6	(0.72-11.8)
Burbot	53	13	13.7	(6.7-20.7)	.64	(0.1-2.6)
Drum	14	3	15.8	(14.5-18.9)	1.8	(1.3-3.7)
Shovelnose sturgeon	6	1	32.4	(29.0-39.0)	4.9	(2.8-6.5)
Northern pike	1		24.5		4.4	

* Includes 3 possible hybrid sauger/walleye.

Table 7. Number of sauger marked per run, total marked at large, and number recaptured in Cartersville study section, April and May 1974.

Date	Number Marked Per Run	Total Marked at Large	Number of Recaptures
4/05/74	-	-	-
4/18/74	7	7	-
4/23/74	13	20	-
4/25/74	1	21	-
4/29/74	30	51	1
4/30/74	3	54	-
5/02/74	3	57	-
5/07/74	54	111	2
5/08/74	32	143	3
5/09/74	30	173	2
5/13/74	44	217	4
4/14/74	16	233	4
5/16/74	29	262	1
5/20/74	33	295	2

(Morris 1964, Johnson and Johnson 1971, Madsen 1971, Crowe 1962, Schumacher 1965, Olsen and Scidmore 1962), and, fish might have continually left and entered the area. Thus, the numbers above should not be interpreted as the exact number of sauger present in the population.

Between March 16 and June 17, 1975, three sections of the Yellowstone River were monitored to define relative numbers of sauger and walleye as one of the primary objectives. The areas monitored were directly below the Cartersville diversion near Forsyth, below the mouth of the Tongue River near Miles City, and below the Intake Diversion at Intake. The Intake section was also sampled in 1976.

The Cartersville diversion section (Figure 7) was monitored with pulsed DC current, from April 20 to June 17. Eight electrofishing runs were made. Seventy four sauger and six walleye were captured; of these, sixty two sauger and six walleye were tagged with individually numbered tags. It was not possible to estimate numbers present due to insufficient sample size and number of recaptures (Table 8). Sauger sizes were similar to those taken in this section the previous spring (Table 9).

The Miles City section (Figure 8) was monitored from April 16 through June 17. Fifteen electrofishing runs were made, collecting 151 sauger and 4 walleye. Of these, 141 sauger and 4 walleye were tagged. No estimate of numbers present was made due to the small sample size and low recapture rate (Table 10). Average lengths and weights of sauger were similar to those taken in the Cartersville diversion section during 1974 and 1975 sampling (Table 11). Sixty nine and six tenths percent of the sport species taken in this section were sauger.

The Intake study section (Figure 9) was sampled from May 8, 1975 through June 9, 1975, and from April 7, 1976 through May 18, 1976. During the 1975 sampling period, five electrofishing runs were made, collecting 105 sauger and 26 walleye (Table 12). During the 1976 sampling period, 13 electrofishing runs and 2 seine hauls were made. During this sampling period 714 sauger and 389 walleye were collected (Table 13). Ninety-one sauger and 26 walleye were tagged in 1975 and 600 sauger and 356 walleye in 1976.

Turbidity and high water levels, during the 1975 sampling period, resulted in a small sample size with no recaptures (Table 14).

River conditions were somewhat better in 1976. This, combined with intensive sampling at this site, resulted in a much larger sample size; however, again few fish were recaptured (Table 15).

Sauger were the most abundant game species collected by electrofishing in all three study areas, and were present throughout the year. Seasonally larger concentrations of sauger occurred in portions of the river, some of the sauger collected might be from a resident population of the Yellowstone River and its tributaries.

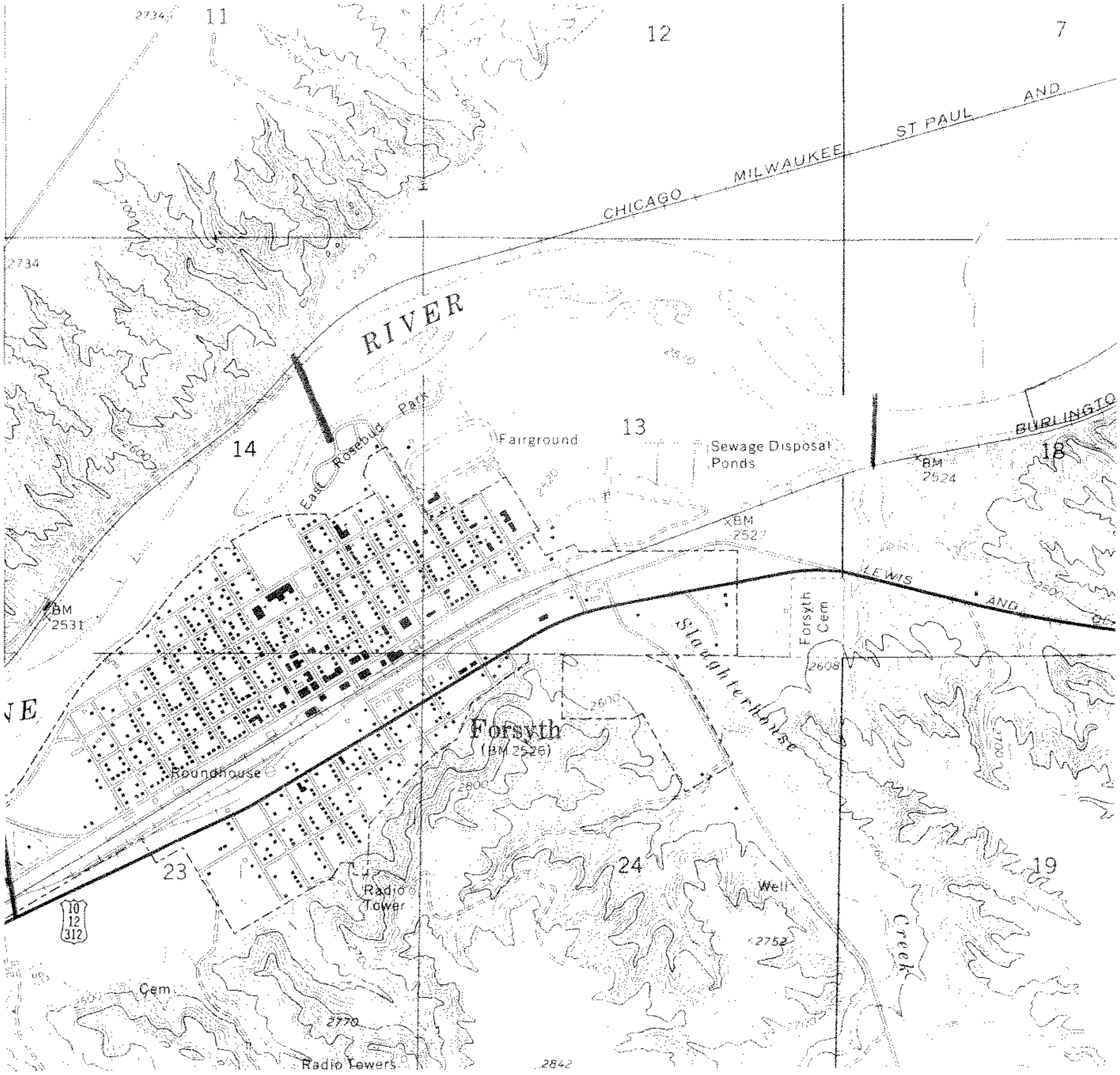


Figure 7. Cartersville diversion study section.

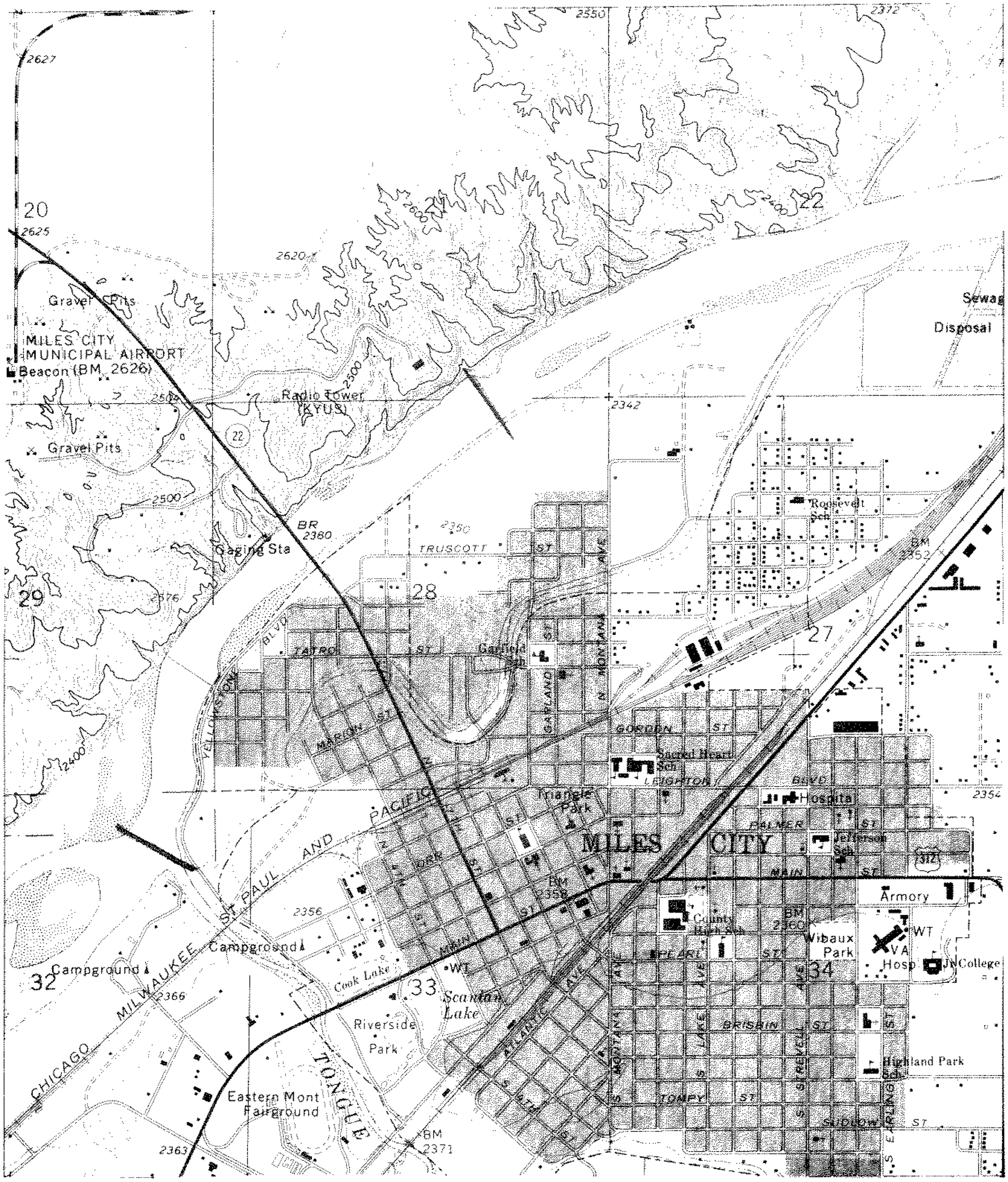


Figure 8. Miles City study section.

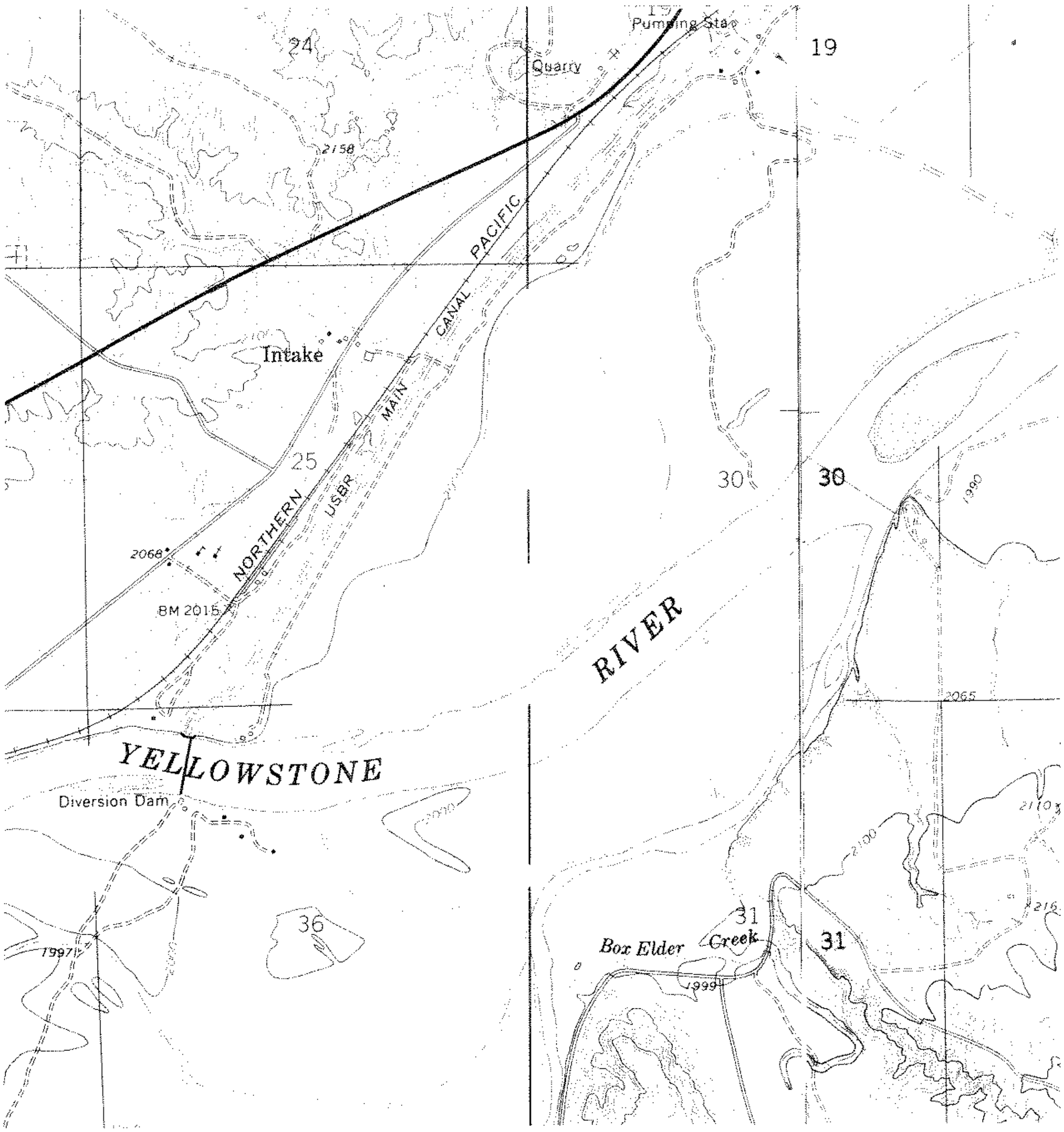


Figure 9. Intake study section.

Table 8. Number of sauger marked per run, total marked at large, and total recaptured in Cartersville diversion section, April, May and June 1975.

Date	Number Marked Per Run	Total Marked at Large	Number of Recaptures
4/20/75	-	-	-
4/21/75	1	1	-
4/28/75	3	4	-
5/02/75	1	5	-
5/07/75	14	19	-
5/12/75	8	27	-
5/21/75	11	38	-
6/03/75	12	50	1
6/17/75	12	62	2

Table 9. Species composition, number and size of electrofishing catch from the Cartersville diversion study section, for April, May and June 1975 (only sport species sampled).

Species	Number	Percent Total	Average Length	Range	Average Weight	Range
Sauger	74	41.8	15.2	(9.4-27.1)	1.2	(0.2-6.3)
Walleye	6	3.4	20.4	(18.1-23.7)	3.1	(1.8-6.0)
Burbot	82	46.3	15.2	(9.5-30.5)	1.8	(0.2-6.0)
Channel catfish	12	6.8	18.1	(14.3-25.5)	2.5	(0.3-6.8)
Northern pike	1	0.5	32.0		8.3	
Brown trout	1	0.5	15.0		1.3	
Drum	1	0.5	16.2		2.4	

Table 10. Number of sauger marked per run, total marked at large, and total recaptured in the Miles CIty section, April, May and June, 1975.

Date	Number Marked Per Run	Total Marked at Large	Number of Recaptures
4/16/75	8	8	-
4/18/75	19	27	-
4/21/75	8	35	-
4/28/75	4	39	-
5/01/75	3	42	-
5/05/75	11	53	-
5/06/75	2	55	-
5/09/75	20	75	-
5/12/75	9	84	1
5/22/75	2	86	-
5/28/75	4	90	-
5/29/75	2	92	-
6/06/75	3	95	-
6/13/75	37	132	1
6/17/75	9	141	-

Table 11. Species composition, number and size of electrofishing catch from the Miles City study section, for April, May and June 1975 (only sport species sampled).

Species	Number	Percent Total	Average Length	Range	Average Weight	Range
Sauger	151	69.6	15.0	(6.5-24.8)	1.17	(0.1-4.5)
Walleye	4	1.8	16.1	(14.1-18.9)	1.16	(0.7-1.8)
Burbot	34	15.7	14.8	(9.5-29.1)	0.89	(0.2-5.8)
Channel catfish	14	6.4	19.5	(12.0-29.4)	3.35	(0.4-8.8)
Smallmouth bass	7	3.2	11.4	(9.7-14.6)	0.70	(0.4-1.7)
White crappie	2	1.0	7.6	(7.4- 7.9)	0.25	(0.2-0.3)
Drum	2	1.0	14.0	(13.5-14.5)	1.17	(0.9-1.4)
Brown trout	1	-	18.2	-	1.90	-
Rainbow trout	1	-	16.7	-	1.50	-
Northern pike	1	-	25.5	-	3.70	-

Table 12. Species composition, number and size of electrofishing catch from the Intake study section for May and June 1975 (only sport species sampled).

Species	Number	Percent Total	Average Length	Range	Average Weight	Range
Sauger	105	40.1	13.1	(9.2-23.0)	0.7	(0.2-3.43)
Walleye	26	9.9	14.4	(5.5-21.1)	1.1	(0.1-3.30)
Channel catfish	9	3.4	16.8	(8.7-30.8)	4.1	(0.3-14.0)
Burbot	17	6.4	13.2	(10.2-23.0)	0.7	(0.1-2.9)
Shovelnose sturgeon	99	37.7	29.2	(10.8-32.8)	1.4	(0.2-5.2)
Pallid sturgeon	1	0.4	52.0		24.5	
Paddlefish	5	1.9	49.8	(47.5-52.0)	34.7	(34.0-36.0)

Table 13. Species composition, number and size of electrofishing and seine catch from the Intake study section for March, April and May 1976 (only sport species sampled).

	Number	Percent Total	Average Length	Range	Average Weight	Range
Sauger	714	56.7	12.2	(6.6-21.1)	.52	(0.1-3.8)
Walleye	389	30.9	15.6	(9.8-27.1)	1.34	(0.2-8.5)
Channel catfish	37	2.9	23.6	(10.3-30.0)	6.60	(0.3-14.25)
Burbot	22	1.7	15.6	(6.4-21.1)	.60	(0.1-1.6)
Shovelnose sturgeon	93	7.4	21.7	(13.7-34.0)	1.39	(0.2-6.5)
Northern pike	1	-	25.9		4.0	
Rainbow trout	1	-	20.2		2.84	
Yellow perch	1	-	6.6		0.10	
Black crappie	1	-	8.4			

Table 14. Number of sauger and walleye marked per run, total marked at large and recaptured in Intake section May and June 1975.

	Sauger			Walleye		
Date	Number Marked Per Run	Total Marked At Large	Number of Recaps.	Number Marked Per Run	Total Marked At Large	Number of Recaps
5/08/75	17	17	-	15	15	-
5/14/75	3	20	-	2	17	-
6/04/75	30	50	-	5	22	-
6/09/75	41	91	-	4	26	-

Table 15. Number of sauger and walleye marked per run, total marked at large and recaptured in the Intake section March, April, and May 1976.

	Sauger			Walleye		
Date	Number Marked Per Run	Total Marked At Large	Number of Recaps.	Number Marked Per Run	Total Marked At Large	Number of Recaps
3/30/76 NS	-	-	-	1	-	-
4/06/76 N	2	2	-	9	10	-
4/07/76 NS	25	27	-	40	50	-
4/08/76 NS	38	65	-	24	74	-
4/09/76 NS	21	86	-	22	96	1
4/12/76 N	33	119	-	41	137	-
4/13/76 NS	49	168	-	31	168	-
4/20/76 NS	69	237	3	48	216	4
4/21/76 N	18	255	-	12	228	-
4/26/76 N	8	263	1	29	257	2
4/28/76 NS	67	330	1	19	276	-
5/04/76 NS*	51	381	-	17	293	-
5/05/76 NS*	64	445	-	15	308	-
5/06/76 NS*	33	478	5	16	324	-
5/10/76 NS*	12	490	-	4	328	-
5/18/76 NS*	36	526	-	4	332	-

N - North side of section
NS- Both sides of section
S - South side of section
* - Night time

Large concentrations of walleye were found to occur in the lower Yellowstone below Intake seasonally. Spring sampling in the Intake section during 1975 and 1976 indicated a relatively large concentration of walleye were present (Table 15). Gill netting during the fall of 1973 (Appendix, Table 5) and electrofishing and seining during the summer and fall of 1975 (Table 16) showed few walleye present in the Intake section. These data indicate the walleye population is migratory, possibly residing in Garrison Reservoir, North Dakota, and utilizing the lower Yellowstone for spawning. Continued tagging and a cooperative study with the North Dakota Fish and Game Department in the lower Yellowstone, its tributaries and Garrison Reservoir, will hopefully define their seasonal movements.

Table 16. Species composition, number and size of electrofishing and seine catch from the Intake study section for summer and fall 1975 (only sport species sampled).

	Number	Percent Total	Average Length	Range	Average Weight	Range
Sauger	95	72.5	10.8	(7.9-18.0)	0.4	(.12-1.5)
Channel catfish	5	3.8	22.1	(10.3-28.8)	5.6	(.32-10.5)
Shovelnose sturgeon	27	20.6	14.8	(11.0-20.0)	0.4	(.12-0.7)
Northern pike	1	0.8	28.2		6.0	
Burbot	2	1.5	21.7	(15.3-28.1)	2.5	(.65-4.3)
Rainbow trout	1	0.8	19.8		2.6	

Spawning Sites

Spawning sauger and walleye were collected at the three study sections to define sauger and walleye spawning periods, physical features associated with spawning sites, and spawning success.

During the April and May 1974 sampling of the Cartersville diversion section, ripe male and female sauger and female walleye were taken in water 1 to 4 feet deep, with a sand or gravel substrate, and moderate current of approximately .5 feet per second. Sampling the same area in 1975 produced ripe male sauger, spent female sauger, and ripe male and female walleye. Ripe male and spent female sauger were taken in areas of similar depths, current velocities and substrate in the Miles City section during the 1975 spring sampling period.

Ripe male and female walleye and sauger were collected in bank vegetation (small willows and grasses) flooded by high water in the Intake section during May and June 1975 (Figure 10). During spring 1976 sampling, these areas were not flooded.

A large partially exposed, gravel bar approximately 1/4 mile below the Intake diversion dam, appeared to be suitable spawning substrate for sauger and walleye (Figure 11). A staff gage was placed at the upstream end of the bar to indicate water depth. Steel posts were placed in the river, downstream from the bar, to attach drift nets for the collection of eggs and fry. The gravel bar consisted of large coarse rubble at the upstream end, changing to finer gravel and sand at the downstream end.

Electrofishing over the gravel bar in the Intake section produced large concentrations of ripe male walleye, but no ripe females. Night beach seining, along the south side of the bar on April 23, produced both ripe male and female walleye. Careful examination of the shoreline along the bar at 2:00 A.M., April 23 revealed sauger or walleye eggs washed up on the shore. Kick samples were taken on April 23, in the area where spawning walleye were collected. Eggs (walleye or sauger) were collected over the coarse rubble and gravel bottom in water ranging from 0.90 to 1.40 feet deep, averaging 1.06 feet deep. Current velocities over the area ranged from 0.35 to 0.87 feet per second and averaged 0.63 feet per second. Eggs were also collected in drift nets on the lower end of the bar on May 4. During the period April 6 through May 11, water levels at this spawning site increased 13.3 inches during the spawning and incubation period. A gradual change in the substrate was observed as water levels and sediment load increased. The clean rubble was covered with finer materials. During the latter part of the sampling period, the entire gravel bar was covered by water. Current velocities were much higher than those recorded when fish were spawning.

As the water level increased, bank vegetation was flooded, providing another potential walleye spawning habitat. However, no eggs were collected in kick sampling of .75 miles of the flooded vegetation along the north bank.

Similar bottom types have been described as suitable and preferred spawning substrate for walleye and sauger in rivers and lakes. Eschmeyer (1950) reported walleye spawning over a lake bottom consisting of a mixture of gravel, rubble and boulders with a substratum of sand and fine gravel. Rawson (1956) reported similar bottom types in tributary streams; Johnson (1961) reported a gravel and rubble bottom to be the preferred walleye spawning sites, and that little or no spawning took place on sand. Although most walleye spawning occurs over rocks and gravel, they also spawn over flooded marsh vegetation (Priegel 1970). Both bottom types are available to walleye spawning in the Yellowstone; however, the type available depends upon discharge during the spawning period. Priegel (1969) reported sauger spawning sites in Lake Winnebago, Wisconsin as bottom areas consisting of sand and fine gravel with a few small areas of rubble and small boulders.

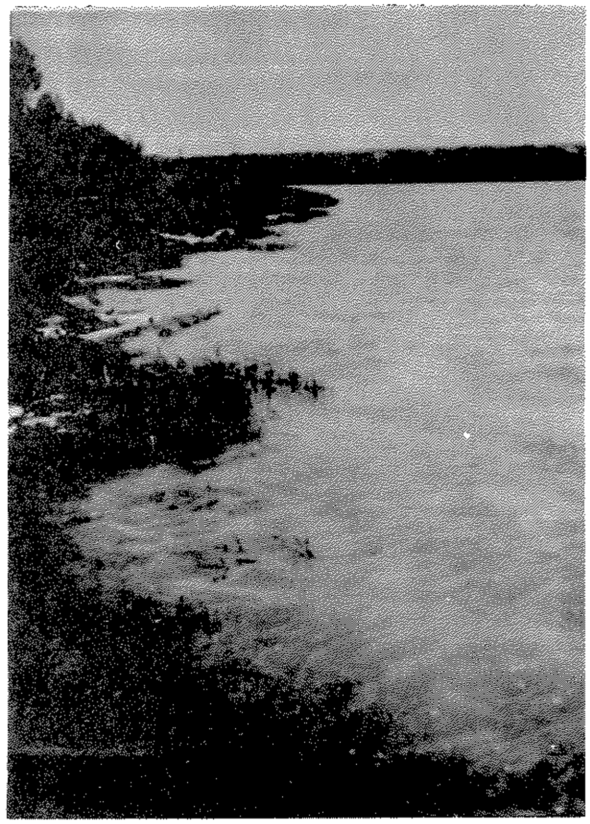


Figure 10. Flooded bank vegetation in the Intake study section.

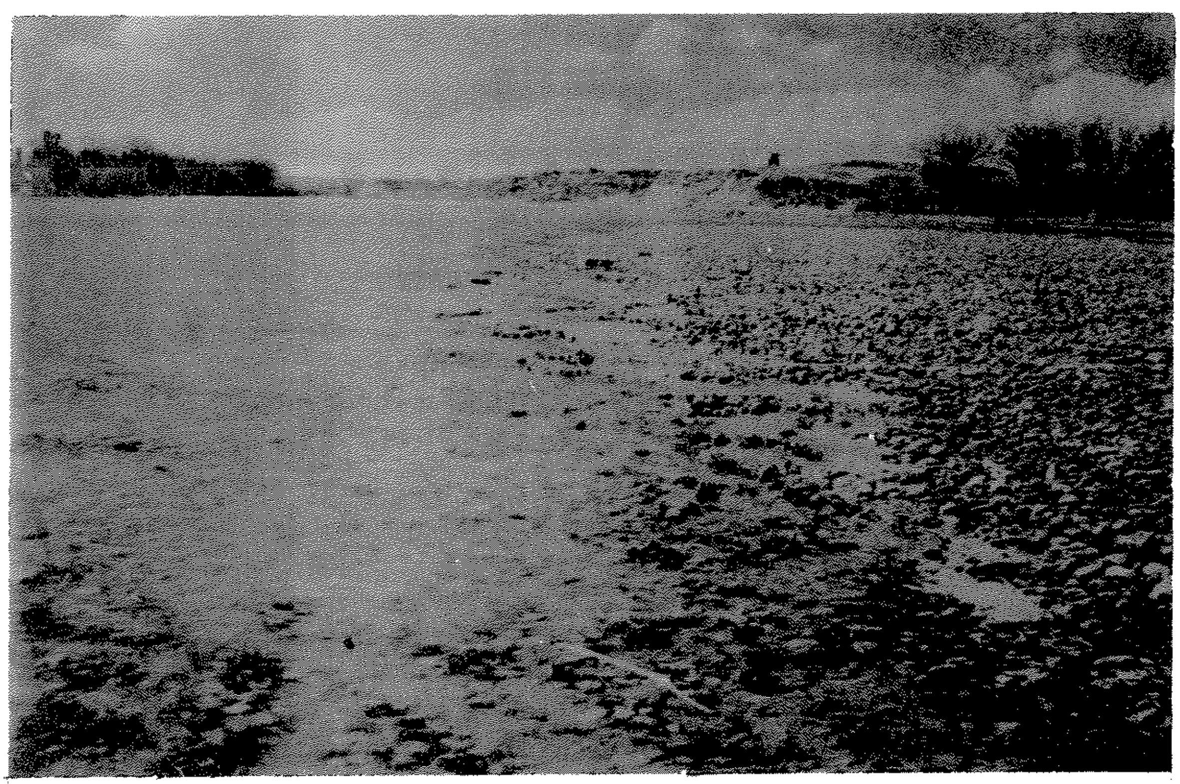


Figure 11. Exposed gravel bar in the Intake study section.

The gravel and rubble areas were the most heavily utilized. Nelson (1965) reported sauger spawning in the Missouri River, below Fort Randall Dam, over a gravel, rubble and boulder substrate. Sauger have not been reported to spawn in areas of flooded vegetation.

Spawning Period and Temperatures

Sauger and walleye were apparently spawning in the Cartersville diversion study section during the April and May 1974 sampling period. The first ripe male sauger and ripe female walleye were taken during the last week of April. Ripe female sauger were not taken until the second week of May. A spent female sauger was taken on May 20 along with several spent female walleyes. Water temperatures ranged from 42 to 61 F during the sampling period. Based on recaptured spent females (walleye and sauger), some spawning was known to have occurred between May 16 and 20, when water temperatures were 45 to 52 F (Figure 12).

Sauger and walleye spawned in the same area in 1975. The first ripe male and spent female sauger were collected May 7. One ripe male and two spent females were taken on May 12. By June 3, all male and female sauger collected had spawned. On May 7, a ripe female walleye was taken. A ripe male and spent female were collected May 12. Water temperatures for the period May through June 17, 1975 ranged from 51 to 60 F (Figure 13).

Spring sampling in the Miles City section in 1975 produced relatively large numbers of ripe male sauger as early as April 16. Ripe males and gravid and spent females were taken during the period April 16 through June 16. Water temperatures in this section were not recorded due to equipment malfunction.

A ripe male and spent female sauger were captured in the Intake section during the first sampling run on May 8, 1975. Ripe male and female walleye were also collected. Ripe male sauger were collected through June 9. The last spent female sauger and last ripe male walleye were taken on May 14. Water temperatures ranged from 49 to 53 F for the May 8 through June 9, 1975 sampling period (Figure 14).

Sampling began in the Intake study section March 30, 1976. Ripe walleye males were first collected on April 6; the first ripe female walleye was collected on April 15. A spent female walleye was taken on April 20. Water temperatures for the period April 6 through May 10 ranged from 54 to 60 F (Figure 15). The first ripe male and spent female sauger was collected on April 7. Mature sauger were captured in the area from April 7 to the end of the sampling period.

Spawning periods and water temperatures for both species overlapped in all sections where both were collected. Water temperatures in the three study sections during spawning periods ranged from 49 to 60 F (April through May). A wide range of water temperatures and dates of walleye and sauger spawning have been reported by others. Morris (1964)

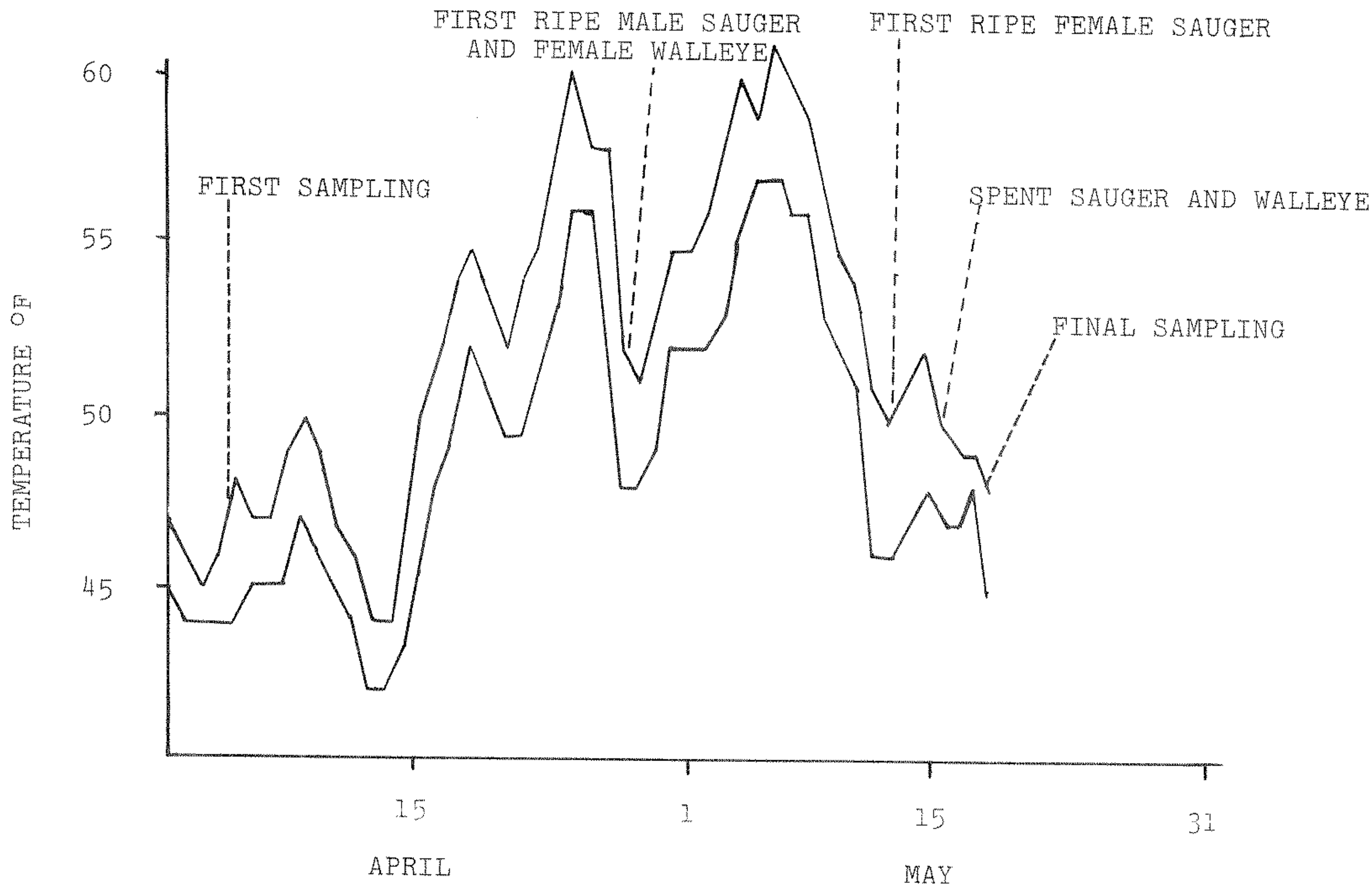


Figure 12. Daily maximum and minimum temperatures at Forsyth during April and May 1974, showing possible sauger and walleye spawning periods.

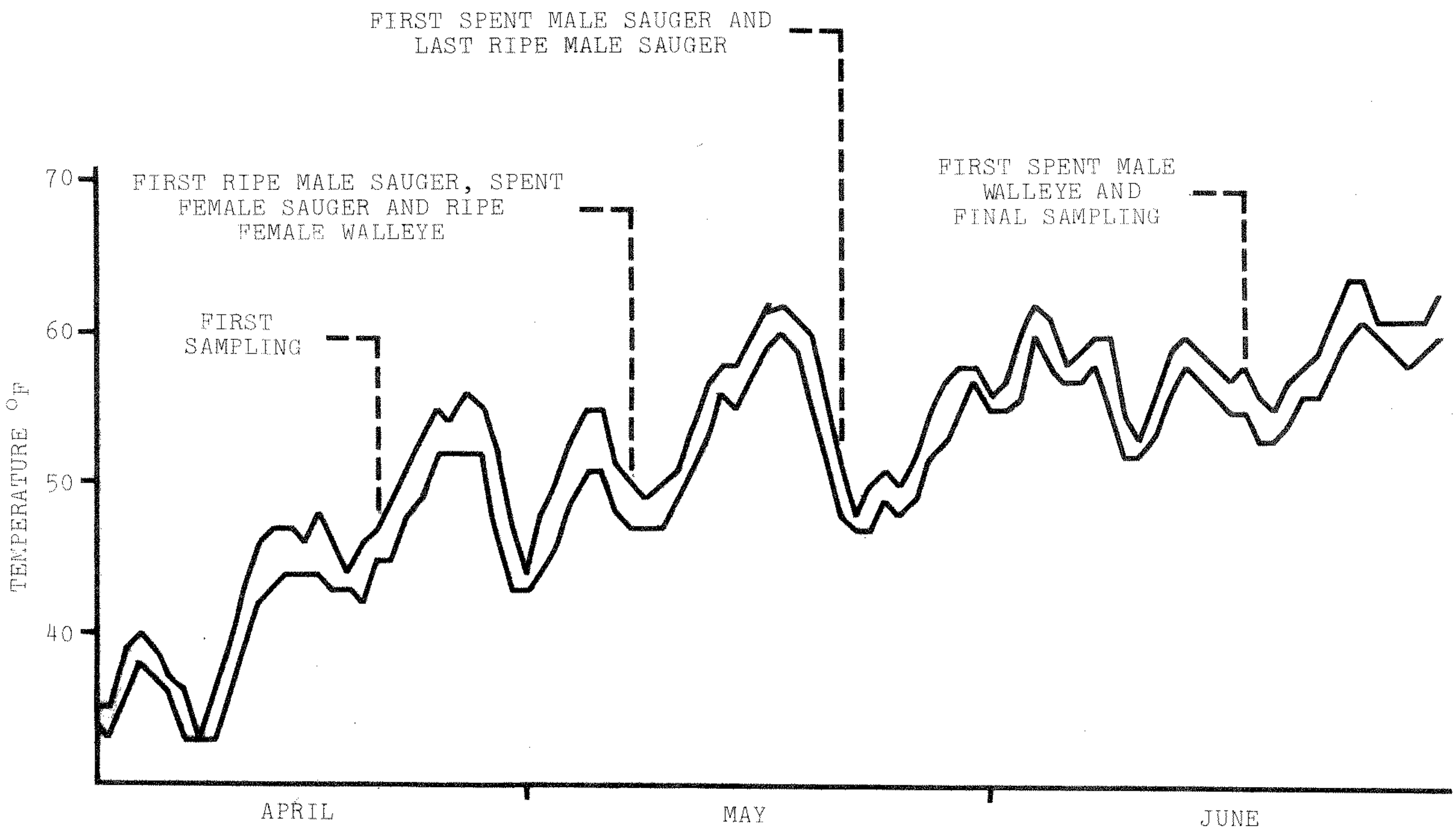


Figure 13. Daily maximum and minimum temperatures at Forsyth during April, May and June 1975, showing possible sauger and walleye spawning periods.

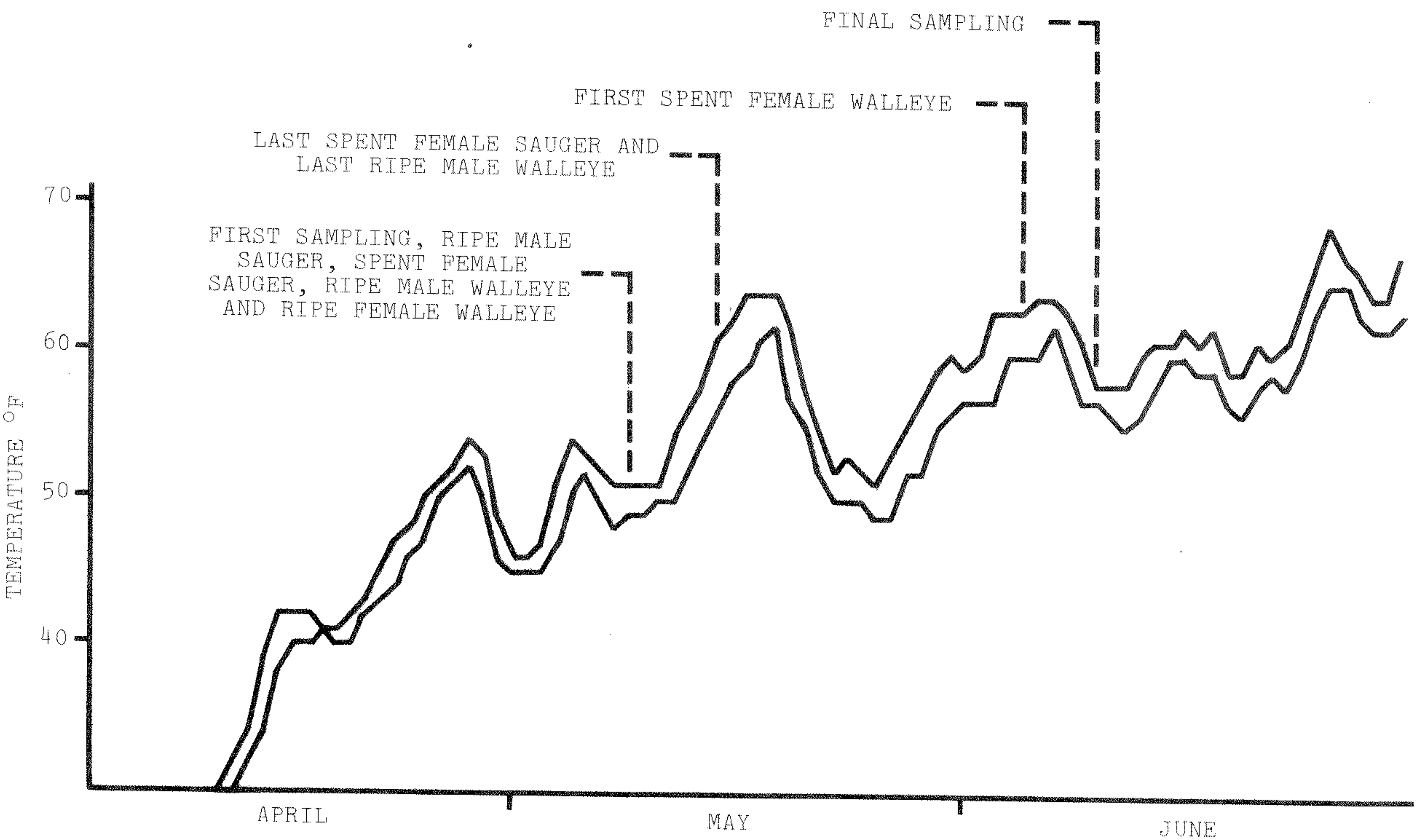


Figure 14. Daily maximum and minimum temperatures at Glendive during April, May and June 1975, showing possible sauger and walleye spawning periods.

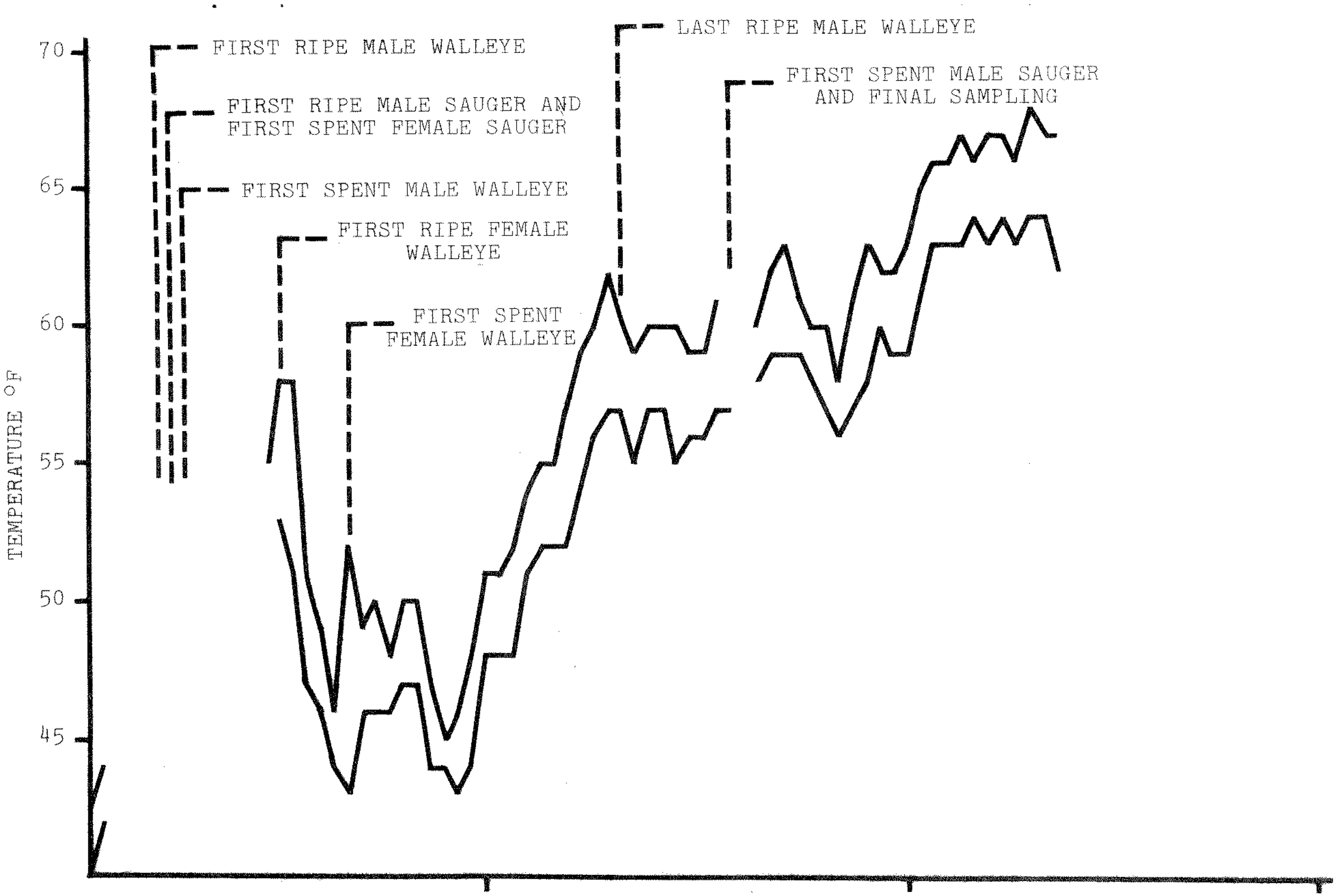


Figure 15 Daily maximum and minimum temperatures at Intake during April, May and June 1976, showi possible sauger and walleye spawning periods.

observed that sauger had not spawned in the Missouri River in Nebraska when water temperatures were 47 F. Nelson (1965) reported sauger spawned in Lewis and Clark Lake, South Dakota between April 27 and May 11. The peak of spawning occurred between April 29 and May 4, when water temperatures were 42 and 43 F. Priegel (1969) reported spawning of sauger in Lake Winnebago, Wisconsin from May 2 to 9, when water temperatures ranged from 43 to 49 F. Eschmeyer and Smith (1943) found that sauger spawning did not take place in Norris Reservoir, Tennessee when water temperatures were below 50 F. Walleye spawned at water temperatures between 43 and 62 F in Spochr's Marsh, Wisconsin (Priegel 1970). Eschmeyer (1950) reported walleye spawning at water temperatures between 44 and 49 F in Michigan.

Egg and Fry Collections

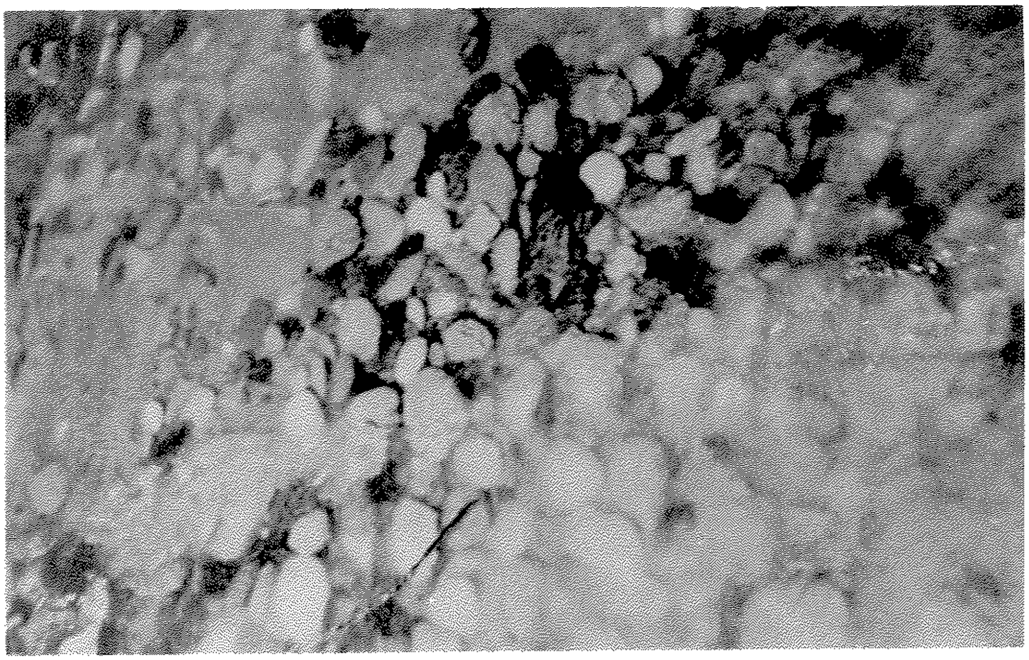
Extensive sampling with drift nets in the Intake section, below known spawning areas, produced few sauger or walleye eggs and no fry. Round 20 inch drift nets were fished a total of 34 hours downstream from known spawning areas. Thirty sauger or walleye eggs were collected in one sample taken at 2:00 a.m. May 4, 1976.

Kick samples, with a window screen dip net, were taken in water up to 3 feet deep throughout the entire study section and on gravel bar areas approximately 1.5 miles downstream from the end of the study section. Several types of bottom were sampled: large rubble, gravel, sand, silt, rock riprap, and flooded vegetation. Forty sauger or walleye eggs were collected along the gravel bar in an area of coarse rubble and gravel on April 23 (the day following night collection of spawning walleye by beach seining at the same location). Attempts to incubate and hatch these eggs for positive identification were unsuccessful.

Walleye yolk sack larvae were collected in drift samples from the Yellowstone River, near its mouth, between May 18 and June 3, 1976, by the U. S. Fish and Wildlife Service, North Central Reservation Investigation Team (Lance Beckman, personal communication).

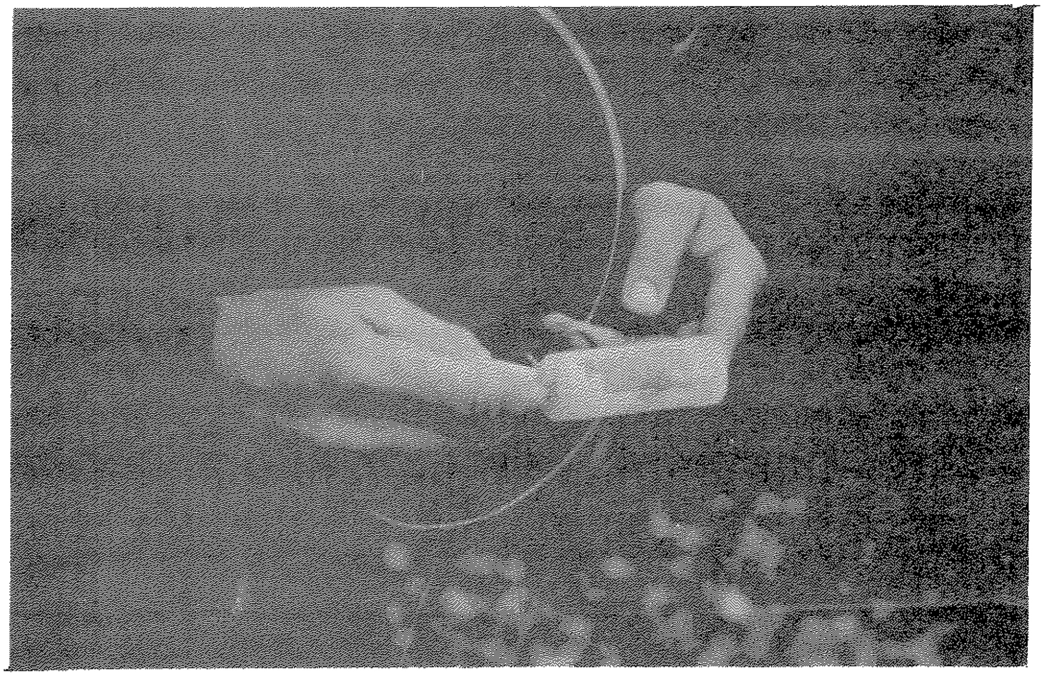
Egg Development

Eggs were stripped from a ripe walleye into a plastic bucket and immediately fertilized with milt from 5 males (all captured in the same seine haul) at 1:00 a.m. on April 23, 1976. After water hardening for approximately 6 hours, they were transferred into 18 small perforated plastic containers (approximately 200 per container) and attached to 3 steel posts (6 containers per post) in the river 500 yards downstream from the Intake dam. By April 27, all but 5 containers had silted in or were pulled from the posts by floating debris. By May 9, all but one container had been lost and most eggs in it were dead or badly infected with fungus. Approximately 50 remaining live eyed eggs were transferred to a clean container and replaced in the river, but were lost by the next day. These eggs had been developing for 14 days at a mean temperature of 50 F. When last observed (May 9), moving embryos were clearly visible and the eggs were flaccid, indicating they were probably close to hatching.



Typical rubble sand substrate utilized by spawning sauger and walleye.

Sauger or walleye eggs washed on shore by strong winds in the Intake section.



Plastic container with walleye eggs used in egg development studies.

Six containers with fertilized sauger eggs were attached to a post in the Intake irrigation canal below the headgate (instead of the main river channel) to protect them from debris, but were immediately removed by vandals.

Priegel (1970) reported eyed walleye eggs were found in Spochr's Marsh, Wisconsin 7 to 14 days after the peak spawning period; however, most years, 13 to 14 days were required before they became eyed with water temperatures ranging between 36 and 66 F during egg development. The incubation period for sauger eggs in a hatchery was 13 to 15 days at 51 F (Nelson, 1965).

Age and Growth

Age determinations were made from scale samples of 79 sauger collected in the Cartersville diversion section in 1974, and from 413 sauger collected from Forsyth to Sidney in 1975. Sauger from the 1974 sample ranged from 6.6 to 20.7 inches, for age groups I through VII. Average annual growth rates for the sample was 2.10 inches (Table 17).

Table 17. Age and growth of Yellowstone River sauger collected from Forsyth study area during April and May 1974.

Age Group	Number of Fish	Length Range	Mean Length (in inches)	Average Annual Growth
I	1	6.6 -	6.6	
II	9	9.7 - 11.1	10.4	3.8
III	14	11.2 - 13.8	12.1	1.7
IV	27	12.6 - 16.4	13.9	1.8
V	13	14.2 - 17.1	14.5	0.6
VI	7	16.9 - 20.7	18.3	3.8
VII	7	18.5 - 20.6	19.2	0.9

Sauger from the 1975 sample ranged from 6.5 to 24.8 inches for age groups I through VII, with an average annual growth rate of 2.38 inches (Table 18).

Table 18. Age and growth of Yellowstone River sauger collected from Forsyth, Miles City, Intake, and Sidney, spring and summer, 1975.

Age Group	Number of Fish	Length Range	Mean Length (in inches)	Average Annual Growth
I	44	(6.5 - 9.8)	8.3	
II	82	(9.2 - 11.0)	10.1	1.8
III	67	(10.7 - 15.6)	12.2	2.1
IV	85	(10.8 - 17.1)	14.0	1.8
V	78	(11.3 - 19.3)	15.5	1.5
VI	50	(16.5 - 24.8)	19.1	3.6
VII	7	(19.7 - 24.5)	22.6	3.5

Age and growth data for other sauger populations in Montana are presented in Table 19. Carufel (1963) reported similar growth rates for sauger from the Garrison Reservoir tailrace (2.26 inches); average annual growth rates for sauger from Garrison Reservoir were somewhat higher (3.07 inches).

Table 19. Age and growth of sauger from several locations in Montana (data from Peters 1964).

Location	Year Collected	I	II	III	IV	V	VI
Marias River	1961	4.4	8.0	11.1	13.2	15.1	18.3
Mild River	1960	5.1	9.7	12.7	14.4		
Fort Peck Res.	1948	5.1	8.8	11.7	14.3	16.9	19.4
Fort Peck Res.	1949	4.8	9.6	12.8	15.3	14.6	19.2

It is possible that this group of fish is not one distinct population, but instead is comprised of fish which reside in both the lower Yellowstone River and Garrison Reservoir, with fish from Garrison moving into the lower Yellowstone seasonally to spawn.

Too few walleye were collected in 1974 and 1975 to make an age and growth analysis. Scale samples for sauger and walleye collected in 1976 have not been prepared for analysis.

Movements

Twelve hundred sixty sauger and 372 walleye were tagged with individually numbered Floy anchor tags during the period September 1973 to May 1976. Thirty-two tagged sauger were caught by anglers and 25 were recaptured by Montana Department of Fish and Game personnel. Nine walleye were recaptured by department personnel and 2 were caught by anglers. Movements of tagged walleye and sauger are presented in Tables 20 and 21. Too few fish have been recaptured to show definite movement patterns.

Movement patterns of sauger have not been well documented. Posewitz (1963) investigated movements of sauger in the Missouri River and tributaries between Fort Peck Reservoir and Morony Dam, and reported maximum upstream movements of 58 miles. Morris (1969) reported downstream movements of up to 77 miles below the stilling basin of Gavin Point Dam on the Missouri River, Nebraska.

Movements of the walleye have been extensively studied, particularly those associated with spawning. Rawson (1956) and Smith et al. (1951) documented walleye spawning movements of up to 39 miles up the Muskegon River in Michigan.

Burbot

The burbot is native to Montana and is found throughout the Missouri, Saskatchewan and Kootenai River drainages (Brown 1971). It is common in the Yellowstone River near Big Timber to its confluence with the Missouri, and is found in the lower reaches of some of the Yellowstone's major tributaries, including the Bighorn and Tongue Rivers.

Angling for burbot is a popular late winter and early spring form of recreation on the Yellowstone River. Popular angling sites are located below irrigation diversion structures and at the mouths of tributary streams. Most angling is done during the late evening, corresponding to the burbot's feeding habits. Occasionally, burbot are caught during daylight. Good catches are made by anglers from late February through early April.

Table 20. Movement of tagged walleye in the lower Yellowstone River by location and river mile.

Location		Intake	Powder River	Miles City	Forsyth
River Mile		71	149	185	237
Date Tagged	Date Recaptured				
4/29/74	5/07/76				T-R
4/20/75	5/12/76				T-R
5/05/75	4/20/76			T-R	
6/04/75	10/01/75	T----------	----------R		
6/09/75	4/07/76	T-R			
4/07/75	4/20/-6	T-R			
4/08/75	4/12/76	T-R			
4/09/75	4/20/76	T-R			
4/12/75	4/20/76	T-R			

Table 21. Movement of tagged sauger in the Lower Yellowstone River by location and river mile.

Location		Intake	Powder River	Miles City	Hathaway	Forsyth	Bighorn	Waco
River Mile		71	149	185	200	237	296	311
Date Tagged	Date Recaptured							
4/17/74	4/22/75			R-------	-------	-------T		
4/29/74	4/28/75					T-R		
5/08/74	6/03/75					T-R		
5/08/74	9/12/75					T-R		
5/13/74	7/ /75*					T-R		
5/13/74	5/05/75			R-------	-------	-------T		
5/13/74	9/22/74					T-------	-------	-------R
5/14/74	5/26/74					T-R		
5/14/74	5/26/74					T-R		
5/16/74	5/28/74					T-R		
5/16/74	5/28/74					T-R		
5/16/74	9/01/75					T-R		
4/20/74	5/27/74					T-R		
5/20/74	5/26/74					T-------	-------R	
5/20/74	7/26/74					T-------	-------R	
5/20/74	5/01/75			R-------	-------	-------T		
5/20/74	6/17/75					T-R		
10/22/74	9/10/75			T-R				
11/20/74	10/05/75	T-R						
4/28/75	5/09/75			T-R				
4/28/75	9/27/75			T-R				
5/02/75	6/03/75					T-R		
5/06/75	5/14/75			T-R				
5/07/75	6/17/75					T-R		
5/07/75	6/17/75					T-R		
5/09/75	9/03/75			T-------	-------	-------R		
5/09/75	4/22/75							
5/09/75	4/30/75			T-R				
5/12/75	6/ /75*			T-------	-------R			
5/28/75	6/13/75			T-R				
5/29/75	9/14/75		T-------	-------R				
6/03/75	10/07/75			T-R				
6/09/75	9/13/75	T-------	-------	-------R				
6/13/75	8/23/75			T-R				
4/06/76	4/20/76	T-R						
4/13/76	4/20/76	T-R						

* exact date not available

In spite of its popularity, the burbot was only recently (1975 Montana legislative session) classified as a game fish. Basic information on all aspects of its life history and harvest data are lacking for the Yellowstone.

Burbot investigations were initiated in the spring of 1974 and designed to: 1) develop adequate sampling techniques for burbot in the lower Yellowstone and 2) investigate certain life history aspects of the burbot in the lower river. Investigations were primarily concentrated in a 2 mile section of the Yellowstone below the Cartersville diversion structure at Forsyth where a popular burbot fishery was known to exist.

Sampling Techniques

Five methods were used to capture burbot during late winter and early spring of 1974 and 1975. These included: 1) angling with rod and reel and set lines, 2) hoopnets, 3) a boom electrofishing unit utilizing AC current, 4) a mobile electrode utilizing DC current. and 5) a boom electrofishing unit utilizing pulsed DC current.

Angling at night with live minnows proved to be the most successful means of collecting burbot during March and April following ice out. Set lines and hoop nets could not be fished in suitable areas due to high current velocities and debris.

The DC mobile electrode unit was ineffective in main channel areas due to the small electrical field produced and low current output inherent in the system. Although the AC boom electrofishing unit produced a much larger field and had a greater current capacity, this system was still largely ineffective, since the response of the burbot to AC current was very poor. Response was further diminished by the cold water temperatures in late winter and early spring.

A spherical electrode array system, using pulsed DC current, was designed and tested during spring 1975 (see Methods section). Burbot exhibited better response to pulsed DC than to AC, and were easily seen and netted.

Burbot Catch Statistics

Burbot were collected by department personnel during late winter and spring of 1974 by angling, setlines and electrofishing with AC. During the same time period in 1975, burbot were collected by angling and electrofishing with pulsed DC. Average lengths, weights, and ranges are presented in Table 22.

Table 22. Number and size of burbot collected by department personnel at the East Rosebud Fishing access site at Forsyth, Montana during spring 1974 and 1975.

	Number Fish	Average Length	Range	Average Weight	Range
Hook and line, 1974	75	16.7	8.5 - 24.1	0.79	0.1 - 2.52
Electrofishing AC 1974	53	13.7	6.7 - 20.7	0.60	0.1 - 2.60
Hook and Line, 1975	92	16.5	9.6 - 27.0	0.86	0.2 - 2.90
Electrofishing DC (pulsed) 1975	82	15.2	9.5 - 30.5	1.78	0.2 - 6.00

Creel Census

During the spring of 1974 and 1975, fishermen were interviewed at the Rosebud fishing access site at Forsyth to obtain information on fishing pressure and harvest. Anglers were interviewed randomly; length of trip and number of fish caught were recorded. In 1975, fish creeled by anglers were weighed, measured, sexed and heads were removed to obtain otoliths. All fish were returned to the anglers cleaned, which was sufficient incentive to provide the creel clerk with all burbot caught.

A summary of the partial creel census conducted at the East Rosebud fishing access site during February and March 1975 is presented in Table 23. The catch of burbot per angler hour for the entire period was 1.77. Catch rates for individual days ranged from 0.68 burbot per hour on February 19 to 5.60 burbot per hour on March 17, 1975.

No creel census information was collected during 1976.

Age and Growth

Otoliths were taken from 91 burbot collected during February and March 1975, and preserved in a 50 percent glycerine solution (Clemens 1950). Ages were determined by the method described by Martin (1940). All otoliths were read within 2 weeks of collection.

Ages were determined for 86 of the 91 fish collected (Table 24). No fish aged was less than 4 years old. The average annual growth between age groups IV and XI was 1.40 inches. The average annual growth

Table 23. Burbot harvest data from angler interviews during February and March 1975 at the East Rosebud fishing access site on the Yellowstone River.

Date	Number of Anglers	Number of Angler Hours	Number Taken	Catch Per Angler Hour	Average Length (in inches)	Length Range (in inches)
2/19/75	5	25.00	17	0.68	16.6	11.8 - 16.8
2/26/75	5	20.00	42	2.10	17.2	10.3 - 26.7
2/27/75	3	12.00	23	1.92	17.2	7.0 - 27.0
2/28/75	3	9.75	20	2.05	17.4	10.2 - 22.0
3/03/75	3	9.00	32	3.56	16.0	10.0 - 28.0
3/04/75	3	8.25	31	3.76	15.7	10.0 - 27.0
3/08/75	3	9.00	13	1.44	13.6	10.0 - 21.0
3/10/75	8	42.00	43	1.02	16.0	14.0 - 28.0
3/17/75	1	2.50	14	5.60	19.4	14.0 - 28.0
3/19/75	2	4.50	16	3.56	14.8	11.7 - 20.0

rate for 107 burbot (ages IV to XI) from Ring Lake, Wyoming was 2.56 inches (Miller 1970b). Clemens (1950) reported an average growth for ages IV to XI from Lake Erie of 0.98 inches. Other reported growth rates varied greatly (Carlander 1969).

Table 24. Age and growth data for 86 Yellowstone River burbot, collected at Forsyth during February and March 1975.

Age Group	Number of Fish	Length Range (in inches)	Mean Length (in inches)	Average Annual Growth
IV	10	10.3 - 15.6	12.01	
V	10	11.0 - 15.5	13.19	1.18
VI	6	15.7 - 18.9	17.01	3.82
VII	30	15.3 - 19.8	17.36	0.35
VIII	9	14.0 - 20.9	18.34	0.98
IX	8	17.4 - 21.7	19.59	1.25
X	6	18.5 - 21.5	20.13	0.54
XI	7	18.5 - 26.7	21.84	1.71

Food Habits

A detailed food habits study was not made during this report period, however, a number of stomachs were examined. The majority of the stomachs collected during the February through March 1975 sampling were empty. The remainder of the stomachs contained primarily three fish species: longnose dace (*Rhinichthys cataractae*), flathead chub (*Hybopsis gracilis*) and young burbot (*Lota lota*).

The adult burbot is highly piscivorous. Hewson (1955), Bonds and Maloney (1960) and Miller (1970a) all report fish as the major food item for adult burbot. Van Oosten and Deason (1938), in a study on Lake Michigan, found that 74 percent (by volume) of burbot stomach contents consisted of fish and 26 percent were invertebrates.

Young burbot apparently rely heavily on aquatic insects. Miller (1970a) found that 1.3 to 2.5 inch burbot from Torrey Creek, Wyoming utilized mayfly nymphs as a major food item. Burbot are primarily nocturnal feeders. They were found to be inactive under bright light, but foraged actively in aquaria in dimmed light (McPhail and Linsey 1970). The burbot apparently does not readily feed during the spawning period, but spawned-out fish feed very heavily. McCrimmon (1959) felt that late winter runs of burbot were primarily feeding movements rather than spawning movements.

Spawning

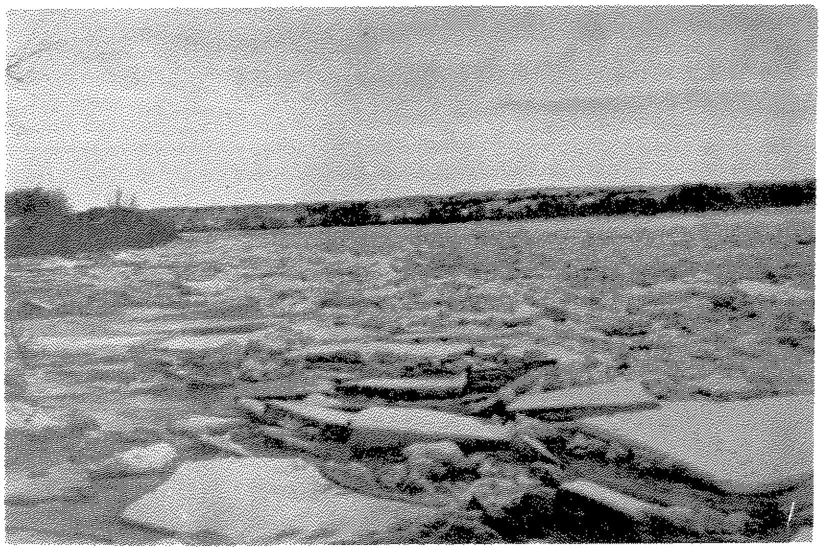
Spawning of the burbot takes place in the winter and probably occurs during January and February (Brown 1971). Gonads of 93 burbot taken from the Yellowstone during late February and March 1975 were examined. No ripe males or females were found; and all fish examined had already spawned. McCrimmon and Devitt (1954) found burbot spawning near the end of January in Lake Simcoe, Ontario and reported that spawning was completed within a week. Peak spawning activity occurred in the second week of February in Burntside Lake, Minnesota between 1931 and 1936 (Cahn 1936). These times approximate spawning periods reported for other populations (Berg 1949; Hewson 1955; Mill 1970a).

Burbot spawn in both lakes and streams. McCrimmon (1959) found that the majority of fish in Lake Simcoe, Ontario spawned in the open lake, with some possibly spawning in rivers. In Lake Simcoe, fish congregated on a shoal 3 to 15 feet deep having a substrate of sand, gravel, smooth rubble and stones. A gentle current passing over the shoal was the only apparent feature which differed from other shoals where burbot did not congregate to spawn. Cahn (1936) observed burbot spawning at night over gravel and sand bottom at depths of 1 to 4 feet in the outlet of Burntside Lake, Minnesota. Bjorn (1940) noted that burbot from Ring Lake, Wyoming, migrated to a tributary spawning area, which was a deep hole in the creek bed approximately 1/2 mile above the lake. Burbot captured while electrofishing in late November 1975 exhibited gonads which were near a mature state; river conditions prohibited further sampling until January, when river ice was safe. Burbot were taken on set lines baited with fathead minnows fished on the bottom through the ice in December. Examination of both male and female gonads indicated the fish had already spawned. Burbot are apparently spawning in the Yellowstone between late November and early January. The specific spawning period, physical parameters and location of burbot spawning sites in the lower Yellowstone will be difficult to determine because severe ice conditions and fluctuating water levels occur during this time period.

Movements

Sixty burbot were tagged during the spring of 1974 and 46 during the spring of 1975, using individually numbered Floy anchor tags. Floy tags were inserted behind the second dorsal fin on fish larger than 12 inches (1974 and 1975), and through the fleshy portion of the tail, anterior to the caudal fin on fish smaller than 12 inches in 1974. Because observations of burbot tagged through the tail showed considerable damage while kept in hatchery raceways, this method of tagging was not used in 1975.

No burbot tagged with Floy tags were recaptured during the report period, which undoubtedly reflects the small number of fish marked.



Severe ice conditions on Yellowstone River near Miles City
January, 1976.

Channel Catfish

Channel catfish are native to the lower Missouri and Yellowstone River drainages in Montana. They are common in the Yellowstone below the Huntley diversion and are found in the lower reaches of the Bighorn, Tongue and Powder Rivers. Channel catfish are one of the most important sport species on the lower Yellowstone. Based on warden creel checks, they account for approximately 25 percent of the angler's catch in the lower River. It was classified as a game fish by the 1975 Montana Legislature.

There are currently little data relating to channel catfish populations in the larger rivers of the northern latitudes. Investigations into the distribution and life history aspects of the channel catfish in the lower Yellowstone were initiated in August 1973.

Standard 125 foot experimental gill nets were the primary tool for capturing channel catfish during the report period. The gill nets were dead set in backwater areas, off the downstream end of islands and gravel bars, and in slow current areas of the main channel. Because large areas of the main channel were not sampled, gill net data were of limited value in determining habitat preferences. Baited hoop nets set in main channel areas were unsuccessful. The lack of success was probably related to the type and location of set rather than to the efficiency of the hoop nets in large rivers (VanEeckhout 1974; C. Wallace, personal communication).

Catch Statistics

A number of channel catfish were taken while sampling for other species during electrofishing operations. The use of electrofishing was apparently selective for large fish. Forty-two channel catfish taken by electrofishing below the Cartersville diversion dam at Forsyth, during April and May 1974 averaged 19.7 inches in length and 3.6 pounds in weight, which was larger than those taken by gill nets (Table 25).

Table 25. Number and size of channel catfish taken in gill nets from Yellowstone River during fall 1973.

Location	Number Net Sets	Number Fish Taken	Avg. No. Fish Per Net	Avg. Length	Range	Avg. Weight	Range
Hysham	15	107	7.13	17.3	(12.2-23.5)	1.7	(0.5-4.5)
Forsyth	24	120	5.00	17.4	(11.0-25.0)	1.9	(0.3-6.5)
Miles City	33	122	3.69	16.3	(9.9-28.0)	1.5	(0.2-6.5)
Terry	6	8	1.33	16.1	(8.8-19.3)	1.5	(0.2-2.7)
Intake	11	26	2.36	17.4	(9.1-24.2)	1.9	(0.2-4.4)

Eighty-nine gill net sets were made in the Yellowstone at five locations: Hysham, Forsyth, Miles City, Terry and Intake, between August and November 1973. Three hundred eighty-three channel catfish were taken (Table 25). Catch rate of channel catfish in the Terry section might have reflected the type of water in which the nets were set rather than the relative abundance of channel catfish in the area. Further work will be done to substantiate this.

Average catch rates for channel catfish from these gill net sets decreased downstream to the Terry sampling area, and increased in the Intake sampling section (see Table 25). Differences in average catch rates for these sampling locations may be related to the number of backwater areas within each section of river. A preference for backwater areas over slow current main channel areas during summer and fall can be illustrated by separating the main channel and backwater sets. The average number of channel catfish per net for 29 nets fished in backwater areas was 9.2, while 50 nets fished in main channel areas averaged 2.3 fish per net (Table 26).

Table 26. Total and average number of channel catfish per net set taken from gill nets set in backwaters and moving water areas at four sampling locations on the Yellowstone River.

	Backwaters			Moving Waters		
Location	Number Net Sets	Avg. No. Fish Per Net	Total No. Fish Taken	Number Net Sets	Avg. No. Fish Per Net	Total No. Fish Taken
Hysham	11	11.6	128	14	1.2	12
Forsyth	9	7.7	70	14	3.6	51
Miles City	7	9.3	65	17	2.0	35
Intake	2	2.5	5	5	3.6	18
Total	29	9.2	268	50	2.3	116

The number of backwater areas decrease from Hysham (river mile 280.0) to Miles City (river mile 185.0). In the vicinity of Terry, the Yellowstone flows in a single channel and few, if any, backwater areas are present. All nets set in the Terry section were in moving water areas.

Spawning

No ripe male or female channel catfish were collected in the Yellowstone during the study period. Eighty-two channel catfish taken in gill nets near Hysham and Miles City during late August 1974, were examined to determine their state of maturity. No females were near a ripe condition. Females taken from gill nets in the same location in September 1974 were still gravid. Extremely cool 1974 summer water temperatures might have resulted in reduced channel catfish reproduction in the Yellowstone.

A ripe female was collected in the lower Tongue River in June 1976 (Robert McFarland, personal communication). Water temperatures, prior to collection, were above 75 F.

It is possible, during certain years, that backwaters, side channels and tributaries are the only places in the Yellowstone which reach and maintain temperatures suitable for channel catfish spawning. VanEeckhout (1974) reported spawning in the Little Missiouri River in North Dakota from mid June to late July at temperatures between 70 and 80 F. Miller (1966) reported optimum spawning temperatures of 80 F, with spawning occuring between 75 and 85 F.

Other physical features found in backwater areas, which may be related to channel catfish spawning, are suitable nest sites including cut banks, rocks, log jams, beaver caches and dens. VanEeckhout (1974) found that channel catfish of the Little Missouri River spawned over rocky areas which provided stable substrates for nest sites and protection of developing embryos. Miller (1966) reported that channel catfish would not spawn in transparent ponds unless they had some type of cover.

Movements

Two channel catfish tagged in the Yellowstone below Intake exhibited extensive upstream movements. One tagged on August 13, 1975 was caught in the Tongue River, four miles above the mouth on May 29, 1976. Another, tagged on May 10, 1976, was caught by an angler near the mouth of Sunday Creek (10 miles downstream from Miles City) on June 4, 1976. VanEeckhout (1974) reported movements of two channel catfish, which were tagged in the Little Missouri River, North Dakota, and caught by anglers in the Yellowstone River near Intake, Montana. He also reported movements of channel catfish from Garrison Reservoir up the Little Missouri River, North Dakota.

Movement patterns of channel catfish have been studied by others. McCammon and LaFounce (1961) reported localized movements of channel catfish in the Sacramento River drainage in California, but also pointed out that the environment suitable for this species was also restricted. Hubley (1963) found that movements of tagged channel catfish from the upper Mississippi River were random. Some fish moved 171 miles downstream in 14 to 16 months and 214 miles upstream in 33 months. Upstream migrations of channel catfish from downstream reservoirs have been documented by several workers (Madsen 1971; Messman 1973).

Forage Fish Survey

The maintenance of the piscivorous sport and non-sport fish populations in the lower Yellowstone depends, in part, on an adequate forage fish base. The major game fish species which commonly utilize other fish for all or part of their diet include walleye, sauger, northern pike, burbot and channel catfish.

A forage fish can be any fish which is utilized by another fish as a food source. Most fish species during their first year of life are small enough to be utilized as food and should, to some extent, be considered as part of the forage base. The availability of age 0 game and non-game species depends, to a large extent, on their habits. Species whose young are pelagic and typically exhibit schooling patterns would be more susceptible to predation than those species whose young do not normally school and commonly seek shelter among the rocks, brush piles or instream debris. Since the habitat requirements of most age 0 stream fishes are poorly understood, it is not possible to determine the availability of age 0 game and non-game fishes as forage at this time.

For purposes of this report, forage fish are defined as those species which, as adults, seldom exceed six inches inches in length. This would include all of the cyprinids and certain others such as the stonecat and mountain sucker. These species usually remain a food source for their entire lives.

Forage fish samples were collected during 1974 in the vicinities of Myers, Forsyth, Miles City, Sunday Creek, Glendive, Intake, and Sidney. The main channel and backwater areas were sampled with a 50 foot x 6 foot x 1/4 inch bag seine and by electrofishing. In 1975 additional samples were collected at eight locations on the lower river: Hysham, Forsyth, Miles City, the mouth of Sunday Creek, the mouth of the Powder River, Terry, Intake, and Sidney. These samples were also obtained from main channel and backwater areas. In addition to the 50 foot x 6 foot x 1/4 inch bag seine and electrofishing, a 100 foot x 8 foot x 1/4 inch loose hung seine was utilized.

Results of the forage fish survey are presented in Table 27. The most common species, the flathead chub and emerald shiner, frequently occur in both backwaters and main channel areas. Two species previously reported from the Yellowstone, the pearl dace and creek chub, (Brown 1971) were not taken during this survey. Brown (1971) classified the creek chub as "quite rare" and the pearl dace as "not abundant."

Notably absent from the forage fish collections is the stonecat. Stonecats generally prefer swift current riffle areas with large gravel or cobble substrates (Trautman 1957). We were not able to sample such areas with the techniques available. Although not collected during current sampling, this species is common in the lower Yellowstone and an important forage fish for some species.

Backwaters

A backwater or slough is an area of standing water or slow current. Backwaters occur at downstream ends of old channels, mouths of slow flowing tributaries and in side channels where minor flows occur through a braided or island section of stream. Backwaters form during intermediate or low flows.

In braided stream sections, islands divide the stream into separate channels which meet and redivide. For braided streams to become stable, the banks must be sufficiently erodable so flow can be diverted around the islands (Leopold et al. 1964). Sediment transport and heterogeneous bed material are also associated with braided streams. Once established, a braided river section may be as close to equilibrium as river sections possessing other patterns (Leopold et al. 1964). Consequently, backwaters would be maintained as a stable habitat component in braided sections of a river, depending on discharge.

Degree of braiding varies along the Yellowstone River with many braided areas from the mouth of the Big Horn River (river mile 296) to Cartersville Diversion (river mile 237), a moderate number downstream to Cheyenne Island above Miles City (river mile 190), none to few downstream

Table 27. Forage fish species for lower Yellowstone River showing location, date of collection, and habitat sampled

BACKWATER			MAIN CHANNEL		
Location	Date	Species	Location	Date	Species
Below Myers Bridge	10-30-74	Emerald shiner Plains minnow	Below Rosebud Diversion	10-17-74	Emerald shiner Plains minnow
Across from Tongue	7-23-74	Plains minnow Emerald shiner Brassy minnow	Above Miles City	7-25-74	Emerald shiner Flathead chub Mountain sucker
Across from Tongue	10-23-74	Plains minnow	Below Tongue	10-16-74	Mountain sucker Flathead chub Plains minnow
Mouth of Sunday Creek	9-12-74	Sturgeon chub			
Glendive	10-9-74	Flathead chub	Across from Hysham Backwater	9-29-75	Flathead chub Lake chub Mountain sucker
	10-10-74	Flathead chub			
	10-18-74	Flathead chub Emerald shiner Lake chub	Across from and above Tongue River	7-24-75	Longnose dace Flathead chub
Hysham	9-29-75	Emerald shiner Mountain sucker	Below Terry	9-30-75	Flathead chub Emerald shiner Silvery minnow
Below Forsyth	9-29-75	Flathead chub Emerald shiner Silvery minnow Fathead minnow Mountain sucker	Below Powder River	9-30-75	Flathead chub Fathead minnow
			Intake	8-21-75	Plains minnow Sturgeon chub Emerald shiner
Cheyenne Island	10-1-75	Flathead chub Emerald shiner Silvery minnow Fathead minnow		9-18-75	Emerald sh Flathead c Longnose Sturgeon

Table 27 continued.

BACKWATER

Location	Date	Species
Below Terry	9-30-75	Flathead chub
		Emerald shiner
		Sand shiner
		Fathead minnow
Intake	10-3-75	Flathead chub
		Sturgeon chub
		Plains minnow
		Silvery minnow
		Emerald shiner
Sidney	10-3-75	Flathead chub
		Emerald shiner
		Silvery minnow
		Fathead minnow

MAIN CHANNEL

Location	Date	Species
Intake	10-3-75	Finescale dace
		Flathead chub
		Plains minnow
		Silvery minnow
		Emerald shiner
Sidney	10-3-75	Flathead chub
		Sturgeon chub
		Fathead minnow
		Silvery minnow
	10-29-75	Flathead chub
		Emerald shiner
		Plains minnow
		Silvery minnow
		Fathead minnow
	10-30-75	Sturgeon chub
		Flathead chub

to Cedar Creek, 12 miles upstream from Glendive (river mile 107), many downstream to near the North Dakota border (river mile 25), and few to none downstream to the mouth.

Backwater areas along the river were sampled during the fall of 1974 to determine which fish species utilized this habitat. Selected backwaters were isolated from the main river channel with 1/2" mesh block net placed across the mouth. Four backwaters located near Hysham, Forsyth, Sunday Creek and Glendive were sampled for species composition. Fish were captured with AC current electrofishing gear and gill nets. Fish population estimates were obtained at the Sunday Creek and Glendive backwaters using only electrofishing gear. Chapman's modification of the Peterson formula (formula 3.7 in Ricker 1975) was used for the calculations. From a total of seven runs in the four backwaters, 21 fish species were collected Carp, river carpsuckers and goldeye were most abundant at 67, 62 and 34 fish per run, respectively. Sauger was the next most abundant species (16.0 per run). Centrarchids were notably more abundant in backwaters than in the main channel. Black and white crappie were the fifth and sixth most abundant species in the backwaters. Yellow perch, green sunfish, pumpkinseed and smallmouth bass were also collected in the backwaters. These fish were rarely collected from the main river channel.

Shovelnose and pallid sturgeon and blue suckers were some of the important species lacking in backwater collections. During the trapping period channel catfish, ling and bigmouth buffalo were collected in relatively small numbers, less than one fish per run. In other random collections in backwater areas channel catfish and bigmouth buffalo were abundant. Seasonal or diel movements of fish may account for periodic fluctuations in utilization of backwaters by some species. Ling may utilize these areas during winter or early spring.

Game fish were the most abundant fish in the Sunday Creek backwater population estimate, while rough fish dominated the Glendive backwater estimate. White crappie and sauger comprised 49 and 23% of the total population estimate at Sunday Creek, respectively. Carp and river carpsuckers dominated the Glendive estimate, comprising 34 and 32% of the estimated total population, respectively. Carp biomass was the largest in both sections, ranging from 36% of the total biomass at Sunday Creek to 60% at Glendive. Although white crappie and sauger comprised 72% of the total number of fish at Sunday Creek, they contributed only 41% to the estimated total biomass. Rough fish accounted for 50% of the total biomass estimate at the Sunday Creek backwater, and 96% at the Glendive backwater.

Backwaters offer habitat diversity in lotic environments. This is reflected in the increased abundance of Centrarchids in these areas. Forage fish were lacking in nearly all collections. Forage fish were undoubtedly more abundant in these areas than collections indicated. Gill nets and electrofishing gear were generally selective for larger fish. Sauger, a piciverous fish, was relatively abundant in these areas, further indication that forage fish were present in backwaters.

Heavy Metals

Pollution resulting from heavy metals can present serious problems for aquatic biota because the metals are stable compounds, not readily removed by oxidation, precipitation, or any other natural process. Heavy metals are usually characterized by their presistance through time even years after pollution sources cease. Proposed development in the Yellowstone River Basin includes several mining operations which could potentially pollute the drainage.

Heavy metals analysis of fish tissues, collected in the Yellowstone River in November of 1976, contributed to the baseline data collection. Fish were collected at four locations along the river and analyzed for cadmium, copper, iron, lead, manganese, mercury, strontium, vadium and zinc (Table 28). This data will provide comparisons for future collections made during and following future development of the river basin.

Table 28. Analysis for heavy metals of fish tissues collected in the Yellowstone River in November 1976.

Collection Site	Species[1/]	Weight (lbs.)	Length (in.)	Heavy Metals (Dry basis ug/gram) Cadmium	Copper	Iron	Lead	Manganese	Strontium	Vanadium	Zinc
Livingston	MWF	0.69	13.5	0.7	3.1	36.0	4.9	4.0	15.50	3.99	66
		0.57	18.8	0.5	3.2	58.0	4.3	4.3	13.98	3.41	60
		0.58	11.7	0.9	2.8	37.5	4.5	4.5	18.37	4.43	104
	LL	1.35	14.9	0.4	2.8	21.0	2.6	1.0	2.99	1.00	16
	CTT	0.88	12.7	<0.2	2.4	11.0	2.6	1.7	2.75	1.10	23
		0.92	12.5	0.3	2.0	12.0	4.5	2.0	2.35	1.01	22
	MSU	0.23	7.7	0.8	2.9	26.5	5.1	15.7	33.87	3.92	32
Huntley	GDE	0.81	13.4	0.2	3.8	34.0	1.9	1.3	1.46	1.04	22
		0.55	12.6	4.8	3.2	35.0	4.1	3.9	29.46	3.93	31
		0.76	12.5	0.5	3.6	31.5	1.3	1.3	2.78	1.31	17
	WSU	2.3	17.0	6.3	3.2	40.0	2.0	0.7	<1.22	0.98	19
		2.1	15.7	0.6	2.1	30.0	1.5	0.8	<1.22	0.84	16
		1.2	13.0	0.4	2.6	24.0	1.5	0.9	<1.22	0.87	15
Miles City	SGR	1.35	13.9	0.6	1.8	17.0	3.0	1.0	2.40	1.20	17
		1.60	17.3	6.2	1.8	19.0	3.7	1.1	5.70	1.82	20
		1.30	15.0	0.6	1.2	11.0	2.8	1.2	4.38	1.39	15
	GDE	1.10	13.2	0.7	5.1	36.0	12.4	2.9	29.41	3.43	41
		0.72	12.4	<0.2	3.2	36.0	2.0	0.8	2.31	0.77	14
		0.85	12.5	4.6	2.0	26.0	4.4	3.1	33.55	3.75	33
	WSU	2.20	16.1	0.6	2.8	41.5	2.5	1.0	<1.22	0.57	20
		1.09	13.8	5.6	3.0	44.5	4.7	4.1	28.35	2.79	22
		2.40	16.2	0.7	3.1	38.0	2.4	2.0	4.37	1.09	24
Intake	SGR	1.4	16.3	0.4	1.7	18.5	1.7	3.0	<1.22	0.64	14
		0.5	11.0	5.9	6.6	57.0	4.1	2.3	5.44	1.81	19
		1.05	14.8	5.5	1.8	21.5	2.4	1.4	4.48	1.63	21
		2.5	28.2	<0.2	2.3	30.0	1.7	1.9	<1.22	0.64	20
		2.8	29.9	<0.2	1.6	18.0	1.0	3.0	<1.22	0.43	22
		0.6	20.0	<0.2	1.7	40.0	1.2	4.7	<1.22	0.73	19
		1.7	12.0	<0.2	2.5	25.5	0.9	2.0	<1.22	0.46	7
		1.0	13.0	4.8	2.0	20.0	4.4	2.0	14.08	2.38	18
		0.8	13.0	0.4	1.9	21.5	2.1	1.0	4.00	1.06	8

1/ SGR - sauger, SNS - shovelnose sturgeon, GDE - goldeye, WSU - white sucker, MWF - mountain whitefish, LL - brown trout, CTT - cutthroat trout, MSU - mountain sucker.

LITERATURE CITED

Beckman, Lance 1976. Personal communication. U.S. Department of the Interior, Bureau of Sport Fisheries and Wildlife, North Central Reservoir Investigations.

Berg, L. S. 1949. Freshwater fishes of the U.S.S.R. and adjacent counties. 4th ed. Zool. Inst. Alcod Nauk. U.S.S.R. 27, 28 and 39. (In Russian: English transl. by Israel Program for Sci. Transl., Jerusalem, 1969).

Bjorn, E. E. 1940. Preliminary observations and experimental study of the ling, *Lota maculosa* (LeSuer) in Wyoming. Trans. Am. Fish. Soc. 69:192-196.

Bliss, O. 1975. Personal communication. Nebraska Game and Parks Comm., Lincoln Nebraska.

Bonde, T. and J. E. Maloney. 1960. Food habits of burbot. Trans. Amer. Fish. Soc. 89:374-376.

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

Cahn, A.R. 1936. Observations on breeding of the lawyer, *Lota maculosa*. Copeia 3:163-165.

Carlander, K. 1969. Handbook of freshwater fishery biology. Iowa St. Univ. Press, Amer. 752 pp.

Carufel, L.H. 1963. Life history of saugers in Garrison Reservoir. J. Wildl. Manage. 27(3):450-456.

Chapman, D.G. and W.S. Overton. 1966. Estimating and testing differences between population levels by the Schnabel Estimation Method. J. Wildl. Manage. 30(1):176-180.

Christenson, L.M. 1975. The shovelnose sturgeon, *Scaphirynchus platorynchus* (Rafinesque) in the Red Cedar-Chippewa River system, Wisconsin. Wisc. Dept. Nat. Res. Res. Rept. No. 82. 23 p.

Clemens, H.P. 1950. The growth of the burbot, *Lota lota maculosa* (LeSuer) in Lake Erie. Trans. Amer. Fish. Soc. 80:163-173.

Coues, Elliot. 1893. History of the expedition under the command of Lewis and Clark. (N.Y.: Frances P. Harper, 4 vols.)

Crowe, W.R. 1962. Homing behavior in walleyes. Trans. Am. Fish. Soc. 9:350-354.

Elser, A.A. and R.C. McFarland. 1975. Task 1: Investigation of aquatic communities - Tongue River. *In*: A study to evaluate the potential physical, biological and water use impacts of water withdrawals and water development on the middle and lower portions of the Yellowstone River drainage in Montana. Annual report (June 25, 1974 to June 30, 1975) to Old West Regional Commission. Mont. Dept. of Nat. Res. and Cons., Helena. pp.24-26.

Elser, A.A., R.C. McFarland, and D. Schwehr. 1977. The effect of altered streamflow on fish on the Yellowstone and Tongue rivers, Montana. Technical Report No. 9, Yellowstone Impact Study. Final report to Old West Regional Commission. Mont. Dept. of Nat. Res. and Cons., Helena.

Eschmeyer, P.H. and C.G. Smith. 1943. Fish spawning below Norris Dam. Tenn. Acad. Sci. 18(1):4-5.

_______________ 1950. The life history of the walleye *Stizostedion uitreum* (Mitchill) in Michigan. Mich. Dept. Conserv., Inst. Fish Res. Bull. No. 3, 99p.

Helms, D. 1974. Shovelnose sturgeon, *Scaphirhynchus platorynchus* (Rafinesque), in the navigational impoundments of the Upper Mississippi River. Iowa fisheries Research, Tech. Series No. 74-3, 68pp.

_________ 1975. Personal communication. Iowa Cons. Comm., Fish. Res. Sta., Bellevue.

Hewson, L. G. 1955. Age, maturity, spawning and food of burbot *Lota lota*, in Lake Winnipeg. Jour. Fish. Res. Bd. Canada 12:930-940.

Hubley, R.C. Jr. 1963. Movement of tagged channel catfish in Upper Mississippi River. Trans. Amer. Fish. Soc. 92:165-168.

Johnson, F.H. 1961. Walleye egg survival during incubation on several types of bottom in Lake Winnibigoshish, Minnesota and connecting waters. Trans. Am. Fish. Soc. 90:312-322.

_________ and M.W. Johnson. 1971. Characteristics of the 1957-1958 and 1939 sport fishery of Lake Winnibigoshish and connecting waters with special emphasis on the walleye populations and catch. Investigational Report No. 312, Minn. Dept. of Nat. Res. 31pp.

Leopold, L.B., M.G. Wolman and J.P. Miller. 1964. Fluvial processes in geomorphology. W. H. Freeman and Company, San Francisco. 522 pp.

Madsen, M.L. 1971. An experimental electric barrier and trap for removing nongame fish from a reservoir tributary. Nebr. Game and Parks Comm. 33pp.

Martin, W.R. 1940. Rate of growth of the ling, *Lota lota maculosa* (LeSuer). Trans. Amer. Fish. Soc. 70:77-79.

Matson, R.E. 1974. Montana Bureau of Mines. Unpubl. Open file Report. Butte.

McCammon, G.W. and D.A. LaFounce. 1961. Mortality rates and movement in the channel catfish population of the Sacramento Valley. Calif. Fish and Game. 47:5-23.

McCrimmon, H.R. 1959. Observations on spawning of burbot in Lake Simcoe, Ontario. J. Wildl. Manage. 23:447-449.

_________, and O.E. Devitt. 1954. Winter studies on the burbot, *Lota lota lacustris* (Walbaum), of Lake Simcoe, Ontario. Can. Fish. Cult. 16:34-41.

McFarland, Robert. 1976. Personal Communication. Mont. Dept. of Fish and Game, Miles City, MT.

McPhail, J.D. and C.C. Lindsey. 1970. Freshwater fishes of northwestern Canada and Alaska. Bull. No. 173. Fish. Res. Bd. Canada. Queen's Printer, Ottawa. 381pp.

Messman, L.D. 1973. Movements, age and growth of channel catfish (*Ictalurus punctatus*) in the Republican River, Nebraska. Unpubl. M. Sc. Thesis, Univ. of Nebr. 93pp.

Miller, D.D. 1970a. Life history study of the burbot. Coop. Res. Proj. 5, Part I, Game and Fish Comm. and Univ. of Wyo. 90pp.

___________. 1970b. Life history study of the burbot in Boyser Reservoir, Ring Lake. Coop. Res. Proj. 5, Part II, Wyo. Game and Fish Comm. and Univ. of Wyo. 56pp.

Miller, E.E. 1966. Channel catfish. Pages 440-463 in Inland Fisheries Management. Calif. Dept. of Fish and Game.

Morris, L.A. 1964. Sauger and walleye investigations in the Missouri River. Nebr. Game and Parks Comm. Job Compl. Rept., Proj. F-4-R-10.

___________. 1969. Sauger and walleye investigation in the Missouri River. Nebr. Game and Parks Comm. Job Compl. Rept., Proj. F-4-R-15.

Nelson, W.R. 1965. Reproduction and early life history of sauger *Stizostedion canadense,* in Lewis and Clark Lake. Trans. Am. Fish. Soc. 97(2):159-166.

Northern Great Plains Resource Program. 1974. Water Work Group Report. Draft. Denver, Colorado.

Novotony, D.W. and G. R. Priegel. 1974. Electrofishing boats - improved designed and operational guidelines to increase the effectiveness of boom shockers. Wisc. Dept. of Natl. Res. Tech Bull. No. 73. 48pp.

Olson, D.E. and W.J. Scidmore. 1962. Homing behavior of spawning walleyes. Trans. Am. Fish. Soc. 91:355-361.

Pelgen, D.E. and G. W. McCammon. 1955. Second progress report on the tagging of white catfish (*Ictalurus catus)* in the Sacramento-San Joaquin Delta. Calif. Fish and Game. 41(4):261-269.

Peters, J.C. 1964. Age and growth studies and analysis of bottom samples in connection with pollution studies. Job Prog. Rept. for Mont. Proj. F-23-R-6, Job No. I & II, 76pp.

Posewitz, J.A. 1963. Missouri River fish population study. Job Comp. Rept. for Mont. Proj. F-11-R-10, Job No. III, 9pp.

Priegel, G.R. 1969. The Lake Winnebago sauger, Wisc. Dept. of Natl. Res. Tech. Bull. No. 43. 63pp.

_______. 1970. Reproduction and early life history of the walleye in the Lake Winnebago region. Wisc. Dept. Nat. Res. Tech. Bull No. 45. 105p.

_______. 1975. Personal communication. Wisconsin Dept. of Nat. Res. Madison.

Rawson, D.S. 1956. The life history and ecology of the yellow walleye, *Stizostedion vitreum,* in Lac La Ronge, Saskatchewan. Trans. Am. Fish. Soc. 86:15-37.

Rehwinkel, B. J., M. Gorges and J. Wells. 1976. Powder River aquatic ecology project. Annual rept. Oct. 1, 1975-June 30, 1976. Utah Internat., Inc., 35pp.

Ricker, W.E. 1975. Handbook of computations for biological statistics of fish populations. Bull. 119 Fish. Res. Bd. of Canada. 300pp.

Schmulbach, J.C. 1974. An ecological study of the Missouri River prior to channelization. Comp. Rept., Proj. B-024-S. Dak. Univ. of S.D., Vermillion. 34pp.

__________. 1974. Personal communication. Univ. of South Dakota, Vermillion.

Schumacher, R. 1965. Movement of walleye and sauger in the upper Mississippi River. Trans. Am. Fish. Soc. 94:270-271.

Smith, L.L., Jr., L.W. Krefting and R.L. Butler. 1951. Movements of marked walleyes, *Stizostedion vitreum vitreum* (Mitchill) in the fishery of the Red Lakes, Minnesota. Trans. Am. Fish. Soc. 81:179-196.

U.S. Geological Survey. 1973. Water resources data for Montana, Part I, surface water records. U.S. Dept. of Interior. 278pp.

VanEckhout, G. 1974. Movement, reproduction and ecological relationships of channel catfish in the Little Missouri River, North Dakota 1972-1973. Unpubl. M. Sc. thesis. Univ. of N.D. 65 pp.

VanOosten, J. and H. J. Deason. 1938. The food of the lake trout *(Christivomer namaycush namaycush)* and the lawyer *(Lota maculosa)* of Lake Michigan. Trans. Amer. Fish. Soc. 67:155-157.

Vincent, R. 1971. River electrofishing and fish population estimates. Prog. Fish Cult. 36(3):182. 163-169.

Wallace, C. 1975. Personal communication. Nebraska Game and Parks Comm., Lincoln.

APPENDIX

Table 1. Size and percent of total catch of fish from 15 gill nets set in the Yellowstone River, Hysham section, fall 1973.

Species	Number	Percentage of Total	Average Length (inches)	Range of Length (inches)	Average Weight (pounds)	Range of Weight (pounds)
Goldeye	628	72.2	12.2	9.4 - 14.9	0.6	0.2 - 0.9
Carp	13	1.5	15.6	12.2 - 21.2	1.7	0.9 - 3.2
Flathead chub	1	.1	7.5	(only 1 taken)	0.1	(only 1 taken)
River carpsucker	53	6.1	13.9	12.1 - 15.5	1.1	0.9 - 1.8
Smallmouth buffalo	5	.6	20.9	18.5 - 23.2	5.1	3.4 - 6.0
Shorthead redhorse	25	2.9	12.7	9.1 - 17.6	1.0	0.3 - 2.2
Longnose sucker	8	.9	12.5	8.1 - 17.0	0.9	0.2 - 1.9
White sucker	6	.7	10.0	7.5 - 12.2	0.4	0.1 - 0.8
Channel catfish	107	12.3	17.3	11.6 - 23.5	1.7	0.5 - 4.5
Stonecat	-	.3	6.9	5.3 - 8.1	0.2	0.2 - 0.3
White crappie	2	.2	7.9	.9 - 8.9	0.3	0.3 - 0.4
Sauger	17	2.0	14.9	13.2 - 17.2	1.0	0.7 - 1.4
Walleye	2	.2	18.4	17.0 - 19.8	2.1	1.8 - 2.4
Total	870					

Table 2. Size and percent of total catch of fish from 24 gill nets set in the Yellowstone River, Forsyth Section, fall 1973.

Species	Number	Percentage of Total	Average Length (inches)	Range of Length (inches)	Average Weight (pounds)	Range of Weight (pounds)
Goldeye	460	54.2	12.3	8.1 - 14.6	0.6	0.1 - 1.3
Northern pike	1	tr 1/	27.7	(only 1 taken)	5.5	(only 1 taken)
Carp	29	3.4	15.6	11.1 - 23.7	2.1	0.7 - 6.3
Flathead chub	15	1.8	7.9	4.2 - 9.1	0.2	0.1 - 0.3
River carpsucker	78	9.2	14.1	7.9 - 18.8	1.3	0.2 - 2.1
Smallmouth buffalo	9	1.1	21.5	18.2 - 23.0	5.5	3.1 - 7.0
Shorthead redhorse	50	5.9	11.8	6.0 - 20.6	0.9	0.1 - 3.8
Longnose sucker	12	1.4	11.1	7.0 - 13.3	0.6	0.1 - 0.9
White sucker	9	1.1	13.2	10.5 - 16.8	1.0	0.4 - 2.1
Black bullhead	1	tr	8.2	(only 1 taken)	0.2	(only 1 taken)
Channel catfish	120	14.1	17.4	11.0 - 25.0	1.9	0.3 - 6.5
Stonecat	4	.5	5.8	5.7 - 5.8	0.3	0.2 - 0.3
Burbot	1	tr	15.5	(only 1 taken)	0.7	(only 1 taken)
Black crappie	6	0.7	6.7	4.8 - 7.7	0.2	0.2 - 0.3
Yellow perch	5	.6	7.1	5.6 - 8.3	0.2	0.1 - 0.2
Sauger	49	5.8	15.4	10.3 - 21.4	1.3	0.4 - 3.8
Total	849					

1/ tr - trace

Table 3. Size and percent of total catch of fish from 33 gill nets set in the Yellowstone River, Miles City Section, fall 1973.

Species	Number	Percentage of Total	Average Length (inches)	Range of Length (inches)	Average Weight (pounds)	Range of Weight (pounds)
Goldeye	961	75.7	11.4	7.7 - 14.2	0.5	0.2 - 0.9
						4.3 - 6.0
Northern pike	2	tr1/	27.0	25.5 - 28.5	5.2	4.3 - 6.0
Carp	17	1.3	16.2	11.0 - 21.5	2.1	0.6 - 4.7
Goldfish	1	tr	9.9	(only 1 taken)	0.6	(only 1 taken)
Flathead chub	8	0.7	7.9	7.1 - 9.3	0.2	0.1 - 0.3
River carpsucker	67	5.3	11.8	7.2 - 16.0	0.8	0.2 - 1.7
Smallmouth buffalo	2	tr	27.2	27.0 - 27.3	12.0	12.0 - 12.0
Shorthead redhorse	16	1.3	13.0	8.8 - 16.7	1.1	0.3 - 2.2
Longnose sucker	11	1.0	13.6	12.4 - 14.7	1.1	0.8 - 1.3
White sucker	6	0.5	11.5	9.3 - 13.3	0.6	0.3 - 1.0
Channel catfish	122	9.6	16.3	9.9 - 28.0	1.5	0.2 - 6.5
Stonecat	2	tr	8.0	7.1 - 8.8	0.2	0.1 - 0.2
Smallmouth bass	1	tr	12.8	(only 1 taken)	1.2	(only 1 taken)
White crappie	3	tr	5.9	5.7 - 6.1	0.1	0.1 - 0.1
Sauger	48	3.8	13.0	8.1 - 19.7	0.7	0.2 - 2.4
Freshwater drum	3	tr	12.1	11.8 - 12.4	0.8	0.8 - 0.9
Total	1270					

1/ tr - trace

Table 4. Size and percent of total catch of fish from 6 gill nets set in the Yellowstone River, Terry Section, fall 1973.

Species	Number	Percentage of Total	Average Length (inches)	Range of Length (inches)	Average Weight (pounds)	Range of Weight (pounds)
Shovelnose sturgeon	1	.3	13.5	(only 1 taken)	0.4	(only 1 taken)
Goldeye	298	80.8	10.9	8.0 - 13.9	0.5	0.1 - 1.0
Rainbow trout	1	.3	18.2	(only 1 taken)	1.53	(only 1 taken)
Carp	2	.6	16.1	10.1 - 22.0	2.6	0.5 - 4.7
Flathead chub	1	.3	9.1	(only 1 taken)	0.2	(only 1 taken)
River carpsucker	23	6.2	11.9	6.1 - 17.4	0.9	0.1 - 2.3
Shorthead redhorse	3	.8	11.3	6.0 - 16.2	0.7	0.1 - 1.3
Longnose sucker	1	.3	14.6	(only 1 taken)	0.6	(only 1 taken)
White sucker	4	1.1	14.1	12.5 - 15.2	1.1	0.8 - 1.3
Channel catfish	8	2.1	16.1	8.8 - 19.3	1.5	0.2 - 2.7
White crappie	2	.6	5.7	5.2 - 6.3	0.1	0.1 - 0.1
Black crappie	1	.3	6.2	(only 1 taken)	0.1	(only 1 taken)
Sauger	23	6.2	12.8	9.0 - 19.4	0.7	0.2 - 2.5
Walleye	1	.3	16.8	(only 1 taken)	1.5	(only 1 taken)
Total	369					

Table 5. Size and percent of total catch of fish from 11 gill nets set in the Yellowstone River, Intake Section, fall 1973.

Species	Number	Percentage of Total	Average Length (inches)	Range of Length (inches)	Average of Weight (pounds)	Range of Weight (pounds)
Shovelnose sturgeon	9	2.8	22.4	13.5 - 27.0	1.1	0.2 - 1.9
Goldeye	211	65.9	10.8	6.0 - 14.2	0.5	0.2 - 1.12
Northern pike	4	1.3	25.8	20.0 - 31.1	4.2	2.2 - 7.5
Carp	5	1.6	15.0	11.0 - 18.4	1.7	0.6 - 3.0
Flathead chub	1	0.3	8.1	(only 1 taken)	0.2	(only 1 taken)
River carpsucker	24	7.5	13.6	8.7 - 18.2	1.3	0.4 - 3.4
Longnose sucker	1	0.3	13.6	(only 1 taken)	1.0	(only 1 taken)
White sucker	1	0.3	13.5	(only 1 taken)	1.1	(only 1 taken)
Channel catfish	26	8.1	17.4	9.1 - 24.2	1.9	0.2 - 4.4
Stonecat	2	.6	7.7	7.1 - 8.2	.2	.2 - .2
Burbot	1	0.3	14.9	(only 1 taken)	0.6	(only 1 taken)
Sauger	34	10.6	13.3	7.9 - 21.0	0.8	0.1 - 3.2
Walleye	1	0.3	14.6	(only 1 taken)	0.9	(only 1 taken)
Total	320					

Table 6. Maximum and minimum water temperatures (F^{o}) for the Yellowstone River at Forsyth, April 1 - September 30, 1974.

Day	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
1	45	47	52	55	50	53	64	65	70	73	59	62
2	44	46	52	55	53	58	61	64	69	72	58	62
3	44	45	52	56	58	61	61	63	68	72	59	63
4	44	46	53	58	58	61	62	64	68	73	60	65
5	44	48	55	60	55	58	63	66	79	74	63	66
6	45	47	57	60	54	57	65	67	71	75	64	67
7	45	47	57	61	57	59	66	68	69	72	64	68
8	45	49	57	60	56	58	66	68	66	79	63	66
9	47	50	56	59	51	54	67	70	65	68	64	67
10	46	49	54	57	54	56	69	70	64	68	62	66
11	45	47	53	55	56	60	67	69	65	68	56	62
12	44	46	51	54	60	64	67	69	64	68	54	56
13	42	44	46	51	63	66	67	70	66	69	54	57
14	42	44	46	52	63	66	68	71	63	67	55	58
15	43	47	47	51	66	68	70	72	63	67	57	61
16	45	50	48	52	61	63	70	72	64	68	60	63
17	48	52	47	49	62	64	71	75	65	79	61	65
18	49	54	47	49	63	64	72	75	66	71	62	65
19	52	55	48	49	63	65			68	72	61	63
20	51	54	46	49	63	65			64	69	59	62
21	49	52	45	46	61	64			63	67	57	61
22	49	54	45	49	60	63			65	69	57	60
23	51	55	49	55	61	65			67	71	57	61
24	53	58	49	59	63	66	72	74	69	72	58	61
25	56	60	57	62	65	67	71	75	70	73	58	62
26	56	58	60	65	64	67	71	74	68	71	59	62
27	52	58	62	65	64	66	71	75	67	70	57	59
28	48	52	58	62	64	65	71	74	66	69	55	57
29	48	51	53	57	63	65	71	74	66	68	52	55
30	49	53	51	53	63	65	70	73	64	66	51	54
31			50	51			71	75	62	63		

Table 7. Maximum and minimum water temperatures (F^{o}) for the Yellowstone River at Miles City, April 1 - September 30, 1974.

Day	APRIL Min.	APRIL Max.	MAY Min.	MAY Max.	JUNE Min.	JUNE Max.	JULY Min.	JULY Max.	AUGUST Min.	AUGUST Max.	SEPTEMBER Min.	SEPTEMBER Max.
1					51	54	65	68	72	73		
2					54	58	63	66	70	72		
3						62	63	65	69	73		
4						63	63	66	68	72		
5					59	62	64	68	69	73		
6					57	60	66	69	71	76		
7					55	58		70	72	73		
8					54	55	68	71	69	72		
9					53	55	69	72	67	70		
10					54	55	70	72	66	71		
11						61			67	69		
12					59	65			65	70		
13					63	67			66	71		
14					65	68			66	69		
15					64	67						
16					63	65			65	69		
17					63	66			66	70		
18					64	67			67	72		
19									69	72		
20									67	70		
21					64	66			66	68		
22					63	65			66	69		
23					63	66			67	70	59	62
24					64	68	74	75	68	71	58	63
25					64	69	72	75	70	72	58	63
26					57	69	72	74		71	59	63
27					66	68	72	75	68	70	57	61
28					65	68	72	75			56	59
29			56	59	64	67	72	74	68		54	57
30			54	57	64	67	71	72			51	54
31			52	54			70	74				

Table 8. Maximum and minimum water temperatures (F°) for the Yellowstone River at Glendive, April 1 - September 30, 1974.

Day	Min.	Max.	Min.	Max.	Min.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
1	46	47	57	58	58	58	61	72	74	70	74	58	64
2	46	47	58	58	59	59	63	70	72	70	74	57	64
3	46	46	58	58	62	62	67	69	72	69	75	57	64
4	46	47	58	59	65	65	69	69	72	69	79	59	66
5	46	48	59	60	65	65	68	71	74	71	76	62	66
6	48	49	60	61	64	64	68	72	75	71	77	63	67
7	49	49	61	62	63	63	67	73	77	71	74	64	68
8	49	50	61	62	61	61	63	74	78	70	74	63	67
9	50	51	61	64	63	63	63	75	79	68	71	61	68
10	51	51	60	63	60	60	63	73	76	67	71	60	66
11	50	50	60	63	60	60	64	72	76	67	70	55	60
12	49	49	60	60	64	64	69	73	76	66	72	52	56
13	49	49	58	60	68	68	73	71	74	67	73	51	59
14	49	49	57	57	70	70	75	71	75	64	70	54	61
15	49	50	57	57	71	71	75	72	78	63	69	57	63
16	49	50	57	57	69	69	73	73	78	63	70	60	65
17	51	51	57	57	69	69	72	73	78	65	71	60	66
18	51	52	56	56	71	71	74	75	80	66	73	61	66
19	52	54	56	56	71	71	75	76	81	66	73	59	64
20	54	55	56	56	73	73	75	78	82	63	67	57	62
21	55	55	55	56	71	71	73	78	82	63	68	55	60
22	55	55	55	55	70	70	72	76	81	64	71	55	67
23	55	55	54	55	70	70	72	76	80	66	71	55	64
24	55	57	55	58	70	70	74	76	80	67	72	57	64
25	57	59	58	60	72	72	76	73	79	68	73		
26	59	60	60	63	73	73	76	72	77	66	71		
27	59	59	63	64	73	73	76	72	77	66	70		
28	58	59	64	64	73	73	75	72	77	63	68		
29	57	58	63	64	71	71	74	72	76	63	67		
30	57	57	60	63	7	71	74	70	72	62	65	48	53
31			58	60				69	74	61	66		

Table 9. Maximum and minimum water temperatures (F°) for the Yellowstone River at Sidney, April 1 - September 30, 1974.

Day	APRIL		MAY		JUNE		JULY		AUGUST		SEPTEMBER	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min	Max.
1			52	57	54	56	67	68	69	71	59	61
2			54	55	55	57	65	67	67	69	58	61
3			52	56	57	60	64	66	66	6k	58	61
4			53	56	69	61	64	67	68	62	59	63
5	42	46	54	58	61	62	65	67	68	63	61	63
6	44	47	55	58	60	62	66	68	69	63	61	63
7	44	46	57	59	60	62	67	70	70	63	61	64
8	44	48	57	59	59	60	69	72	70	63	61	63
9	46	49	57	60	57	60	70	73	68	61	60	63
10	47	49	57	59	56	58	71	73	67	69	62	63
11	44	48	54	57	56	58	71	73	67	69	56	62
12	43	44	53	56	57	61	71	73	65	69	54	56
13	42	45	48	55	61	65	71	73	67	69	52	55
14	43	46	48	52	64	67	70	72	66	69	54	58
15	43	47	50	52	65	68	70	73	64	66	57	61
16	45	50	49	51	65	67	72	74	64	67	60	63
17	47	50	49	51	64	66	72	75	64	68	61	64
18	47	52	49	50	65	67	73	77	66	70	61	64
19	50	55	49	51	66	68	75	78	68	70	60	63
20	52	54	50	51	68	69	71	73	64	69	58	61
21	50	53	47	59	66	69	75	78	62	64	56	59
22	50	54	46	47	65	67	76	78	62	66	55	58
23	50	54	47	49	65	67	74	77	65	69	57	59
24	52	57	48	54	65	67	74	77	67	70	58	60
25	55	59	53	57	67	69	74	76	68	70	58	60
26	57	60	57	61	68	70	72	75	67	69	58	60
27	57	59	60	62	68	70	71	74	65	68	56	59
28	52	57	60	62	68	69	70	73	65	67	54	56
29	52	54	59	61	67	69	70	73	62	65	50	56
30	51	54	58	59	66	68	70	72	61	64	49	51
31			56	58			67	71				

Table 10. Maximum and minimum water temperatures (Fo) for the Yellowstone River at Forsyth, April 1 - September 30, 1975

Date	APRIL		MAY		JUNE		JULY		AUGUST		SEPTEMBER	
	Min.	Max.	Min.	Max.	Min .	Max.	Min.	Max.	Min.	Max.	Min.	Max.
1	34	36	44	48	55	57	63	65	67	69	63	66
2	33	36	46	50	56	60	65	66	66	68	63	66
3	35	39	49	53	60	62	65	68	66	69	62	66
4	38	40	51	55	58	61	65	67	68	71	63	66
5	37	39	51	55	57	58	65	67	67	71	62	66
6	36	37	48	51	57	59	65	68	70	74	63	67
7	33	36	47	50	58	60	63	66	72	74	63	67
8	33	33	47	49	55	60	63	66	69	72	64	69
9	33	36	47	50	52	55	64	66	68	72	66	70
10	36	39	49	51	52	53	65	66	69	73	66	69
11	39	43	51	54	53	56	64	66	69	73	61	66
12	42	46	53	57	56	59	64	66	70	72	61	64
13	43	47	56	58	58	60	64	66	67	70	59	63
14	44	47	55	58	57	59	66	68	64	68	61	65
15	44	45	57	60	56	58	67	69	64	67	62	66
16	44	48	59	62	55	57	68	70	65	68	63	65
17	42	46	60	62	55	58	66	68	64	66	60	63
18	42	44	59	61	53	56	66	68	65	69	56	59
19	41	46	55	60	53	55	65	67	68	69	54	56
20	45	47	52	56	54	57	65	69	68	72	53	56
21	45	49	48	51	56	58	68	71	69	72	54	58
22	48	51	47	48	56	59	69	71	69	73	55	59
23	49	53	47	50	58	62	67	70	68	71	57	60
24	52	55	49	1	60	64	67	70	62	68	58	62
25	52	54	48	50	61	64	69	72	62	64	58	62
26	52	56	49	52	60	61	70	72	61	65	58	60
27	52	55	52	55	59	61	70	73	63	67	58	60
28	47	52	53	57	58	61	72	74	66	70	56	59
29	43	47	55	58	59	61	72	74	66	70	55	58
30	43	44	57	58	60	63	69	71	65	69	54	57
31			55	56			67	70	65	68		

Table 11. Maximum and minimum water temperatures (F^o) for the Yellowstone River at Miles City, April 1 - September 30, 1975.

Date	APRIL		MAY		JUNE		JULY		AUGUST		SEPTEMBER	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
1	33	33					63	67	69	71	65	69
2							65	69	68	71	63	66
3							67	70	68	71	61	68
4							67	69	69	71	63	68
5							66	69	69	72	64	69
6							67	70	70	74	64	68
7							67	69	72	75	63	68
8							64	67	71	73	63	69
9							65	67	71	74	64	69
10							66	68	70	74	65	71
11							65	67	71	75	63	65
12							65	67	71	73	61	67
13							65	68	70	73	60	66
14							66	70	68	70	60	67
15							68	72	67	71	61	67
16							70	72	66	70	62	68
17							70	71	65	69	60	64
18							68	70	66	70	57	61
19							67	69	68	70	54	57
20							66	70	68	72	53	58
21							69	72	68	72	53	58
22							71	73	70	74	54	60
23							71	72	71	73	56	62
24					63	64	69	72	65	72	56	63
25					63	67	70	72	62	65	58	63
26					63	65	71	73	63	67	58	61
27					61	63	72	74	63	68	57	60
28					60	62	72	76	66	72	55	62
29					60	63	73	77	67	72	55	59
30					62	64	72	75	67	72	54	59
31							71	72	66	71		

Table 12. Maximum and minimum water temperatures (F^o) for the Yellowstone River at Glendive, April 1 - Septmeber 30, 1975.

Date	APRIL		MAY		JUNE		JULY		AUGUST		SEPTEMBER	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
1	30	30	45	46	57	60	65	68	70	72	67	68
2	30	30	45	47	57	63	67	69	68	71	66	67
3	30	30	47	51	60	63	69	72	69	72	65	65
4	30	30	50	54	60	63	71	73	68	70	65	65
5	30	30	52	53	60	64	70	72	66	71	64	65
6	30	30	50	52	62	64	70	72	68	74	64	65
7	30	30	48	51	60	63	70	72	71	75	65	65
8	30	30	49	51	57	61	67	70	70	73	64	65
9	30	30	49	51	57	58	66	68	69	74	64	65
10	30	30	50	51	56	58	67	69	70	75	65	65
11	30	32	50	54	55	58	67	69	70	75	63	65
12	32	34	52	56	56	60	66	69	70	74	69	63
13	34	39	54	58	58	61	66	69	68	73	59	64
14	38	42	56	61	60	61	67	71	69	71	60	65
15	40	42	58	62	60	62	69	73	66	70	61	66
16	40	42	59	64	59	61	71	74	65	74	61	65
17	41	41	61	64	59	62	72	73	64	66	60	64
18	40	41	62	64	57	59	71	72	64	68	55	60
19	40	42	57	62	56	59	69	71	67	70	52	55
20	42	43	55	58	58	61	68	71	68	72	51	54
21	43	45	52	55	59	60	69	72	69	70	51	56
22	44	47	50	52	58	61	72	75	68	72	53	58
23	46	48	50	53	60	63	72	74	70	73	55	60
24	47	50	50	52	63	66	70	74	64	72	55	60
25	50	51	49	51	65	69	71	75	62	65	57	62
26	51	52	49	53	65	67	72	75	62	67	57	60
27	52	54	52	55	63	66	72	77	63	68	56	57
28	50	53	52	57	62	64	74	80	66	69	54	60
29	46	49	55	59	62	64	75	82	66	70	55	58
30	45	46	56	60	63	67	75	78	66	69	52	57
31			57	59			72	74	67	69		

Table 13. Maximum and minimum water temperatures (F^o) for the Yellowstone River at Intake, April 1 - June 11, 1976.

	APRIL		MAY		JUNE		JULY		AUGUST		SEPTEMBER	
Day	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
1	40	42	48	51	61	65						
2	42	44	48	52	63	66						
3			51	54	63	66						
4			52	55	63	67						
5			52	55	64	66						
6			52	57	63	67						
7			54	59	64	67						
8			56	60	63	66						
9			57	62	64	68						
10			57	60	64	67						
11			55	59	62	67						
12			57	60								
13			57	60								
14		55	55	60								
15	53	58	56	59								
16	51	58	56	59								
17	47	51	57	61								
18	46	49	57									
19	44	46										
20	43	52	58	60								
21	46	49	59	62								
22	46	50	59	63								
23	46	48	59	61								
24	47	50	58	60								
25	47	50	57	60								
26	44	47	56	58								
27	44	45	57	61								
28	43	46	58	63								
29	44	48	60	62								
30	48	51	59	62								
31			59	63								