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LOWER YELLOWSTONE RIVER FISHERY STUDY
PROGRESS REPORT NO. 1

RESEARCH CONDUCTED BY:

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Since this is a progress report only, results presented herein are not necessarily final, and may be subject to change. For this reason the information contained in this report may not be published or used for other purposes.

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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 the coal resources at the 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.

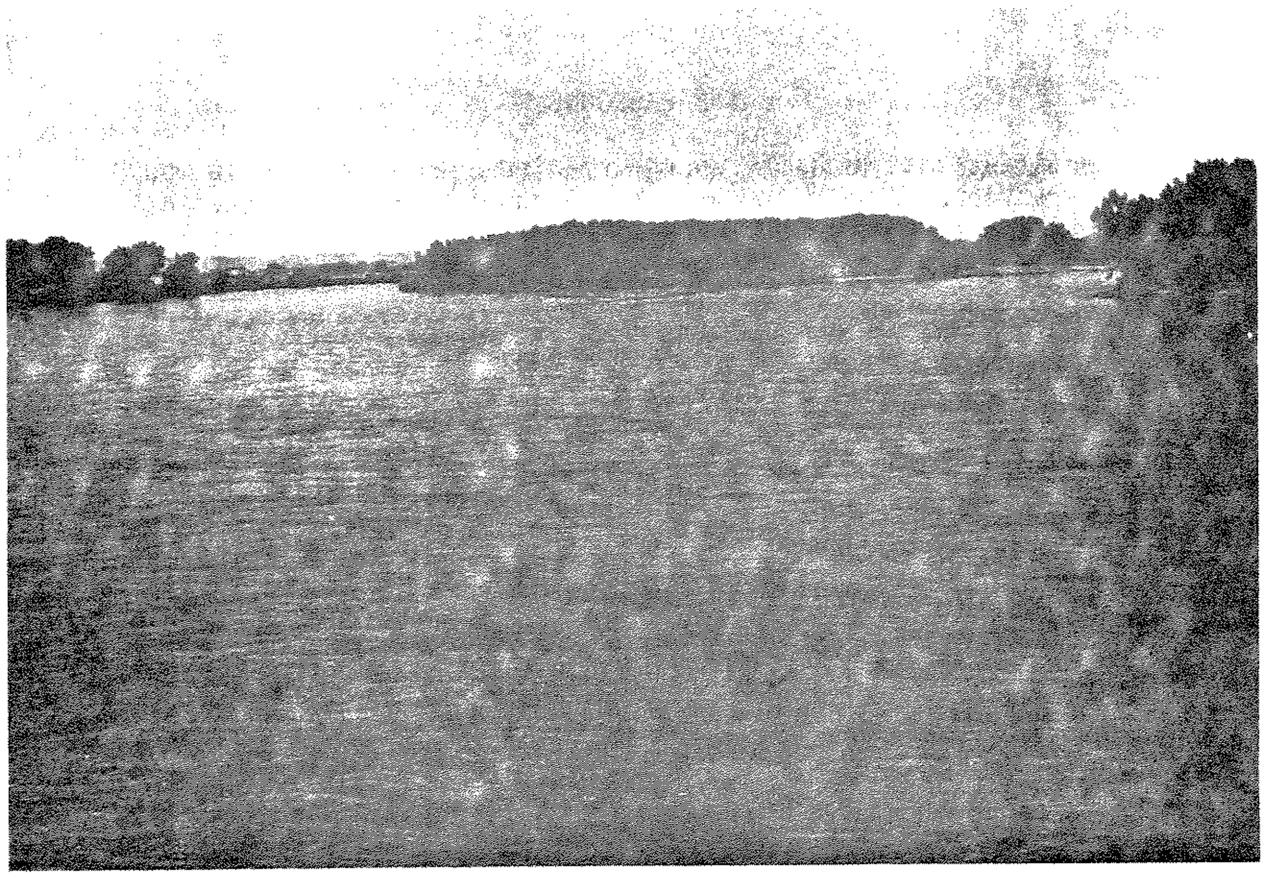
OBJECTIVES

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 encompasses 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, however, 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 entering 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 in Montana 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 as related to fish distribution. From its headwaters in Wyoming to its mouth in North Dakota, the river changes from an alpine, salmonid-type fishery to a diverse, warm-water aquatic ecosystem. A longitudinal profile of the Yellowstone is presented in Figure 2.

The upper Yellowstone, from Gardiner to Big Timber (111 miles), supports cold-water salmonid populations of national significance and has been classified as a Blue Ribbon Trout Stream by the Montana Fish and Game Commission. This area is characterized by large populations of a relatively small number of fish species characteristic of clear, cold water rivers.

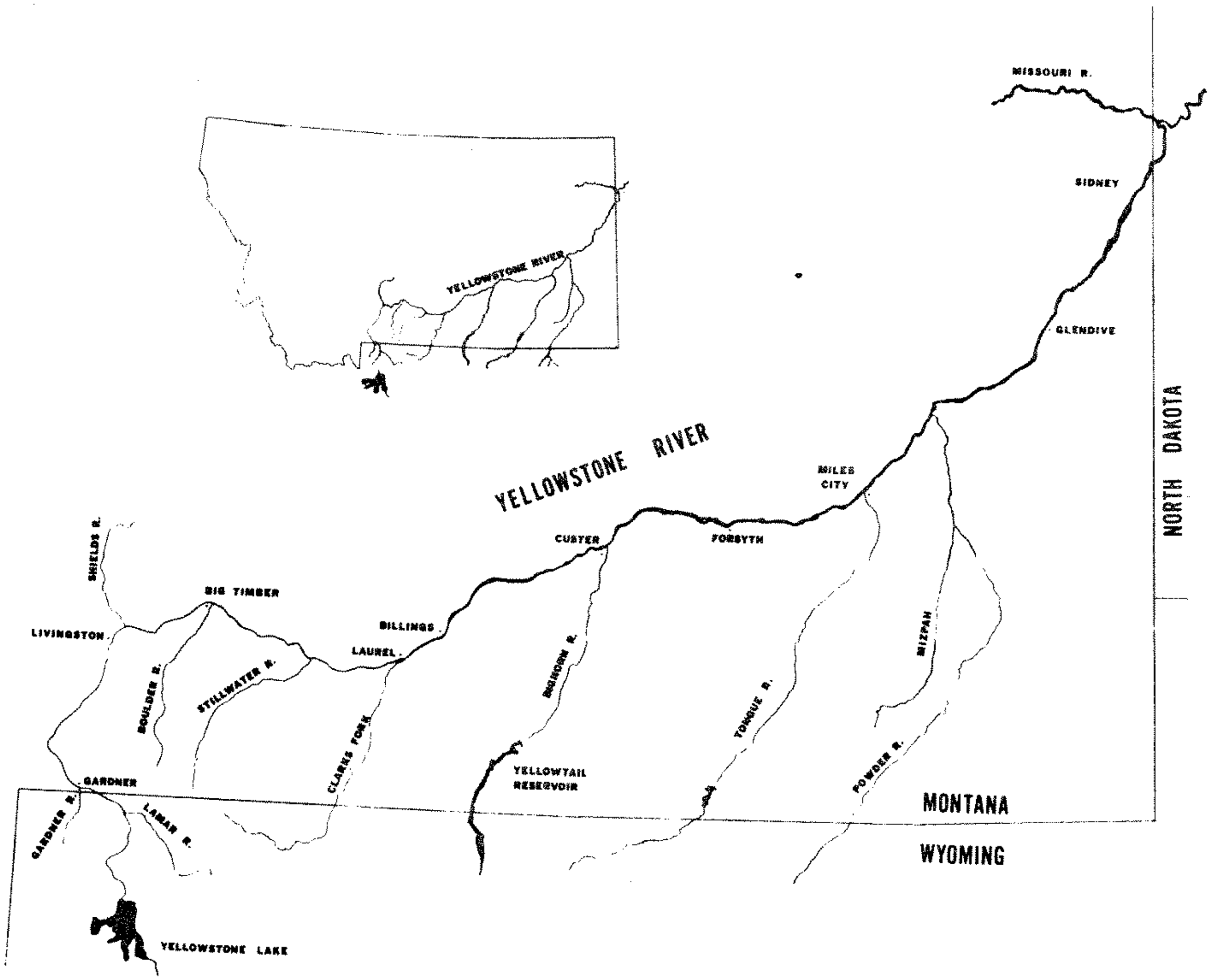


Figure 1. Yellowstone River drainage.

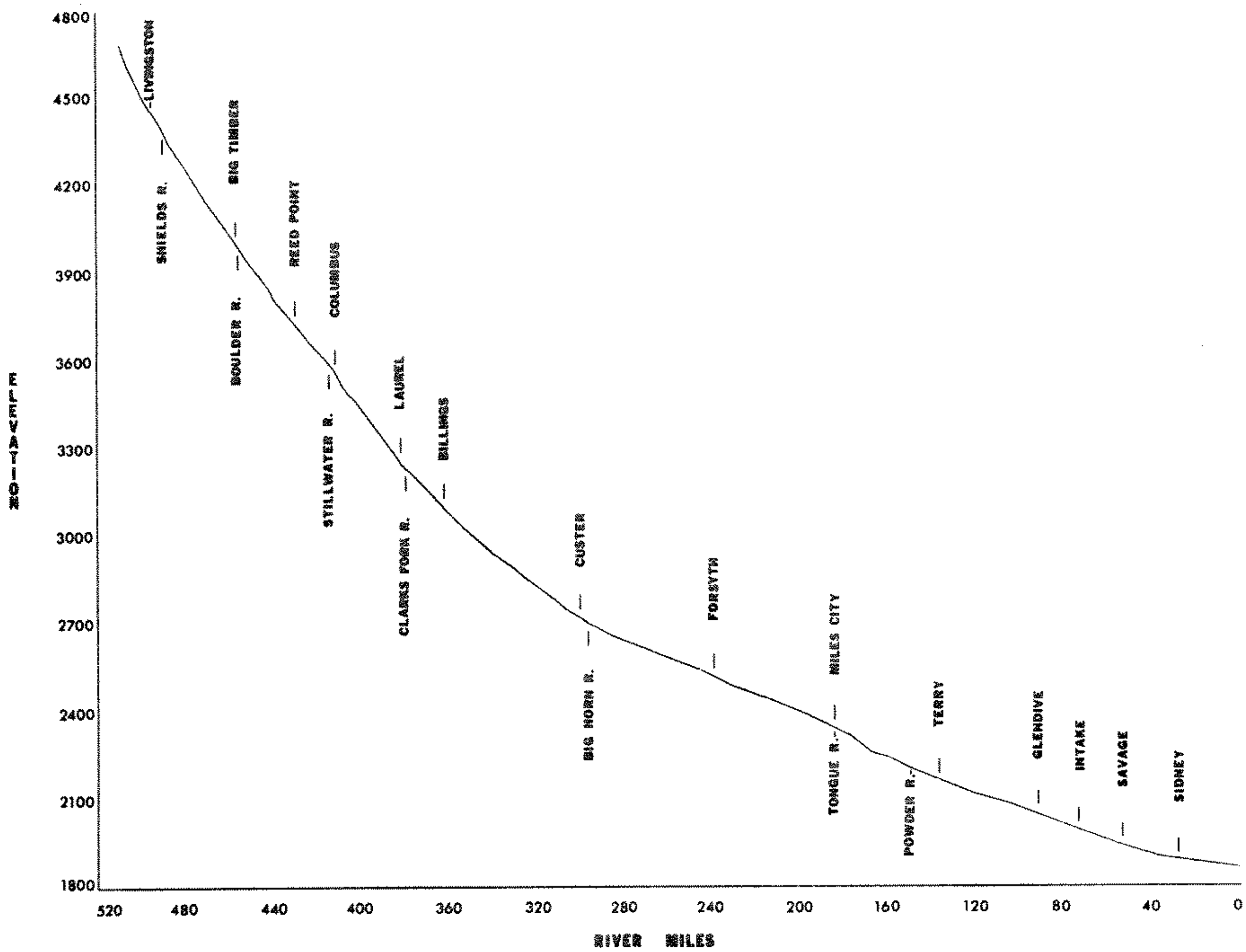


Figure 2. Longitudinal profile of the Yellowstone River from the mouth of Pine Creek to its confluence with the Missouri River.

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).

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
495.5	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

Flow regimens are monitored by U. S. Geological Survey gage stations at two locations on the main stem of the upper Yellowstone. These are located at 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) or 3,100 cubic feet per second (cfs). At Livingston, the average annual discharge (48-year period of record) was 2.70 MAF (3,700 cfs). The highest flow recorded at Livingston was 30,600 cfs (June 20, 1943), while the lowest recorded flow was 590 cfs on January 22, 1940. During the water year October 1972 through September 1973, the maximum recorded flow was 21,000 cfs (June 10, 1973) and 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), contains the 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 their distribution and population dynamics are poorly understood.

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) while the lowest flow recorded was 430 cfs (December 12, 1932). During the 1972-73 water year, the maximum flow of 37,700 cfs was recorded on June 11, 1973, while the minimum flow of 1,100 cfs was 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 295 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 the paddlefish, shovelnose sturgeon, sauger, walleye, channel catfish, northern pike and burbot. In addition, large populations of nonsport species occur which 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 8.216 MAF (11,340 cfs) and 9.44 MAF (13,030 cfs), respectively (USGS Water Resource Data for Montana 1973). The mean annual flow at Sidney adjusted to the 1970 level of water usage is 8.8 MAF (Northern Great Plains Resource Program 1974).

The highest flow recorded at Sidney was 159,000 cfs (June 2, 1921), while the lowest recorded flow 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) and the minimum flow was 3,200 cfs on December 10, 1972 (USGS Water Resource Data for Montana 1973).

A total of 49 species representing 13 families of fish has been recorded for the Yellowstone River in Montana (Table 4). Fishery investigations in areas of the river not previously sampled will likely add new species to the list. The probable distribution of 33 of the 49 species is illustrated in Figure 3.

There is an increase in species diversity progressing downstream on the Yellowstone. In Yellowstone National Park above Tower Junction, the cutthroat trout exists as the only trout species. Eleven species (five families) of fish 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 45 species representing 12 families recorded.

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			

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

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)	
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

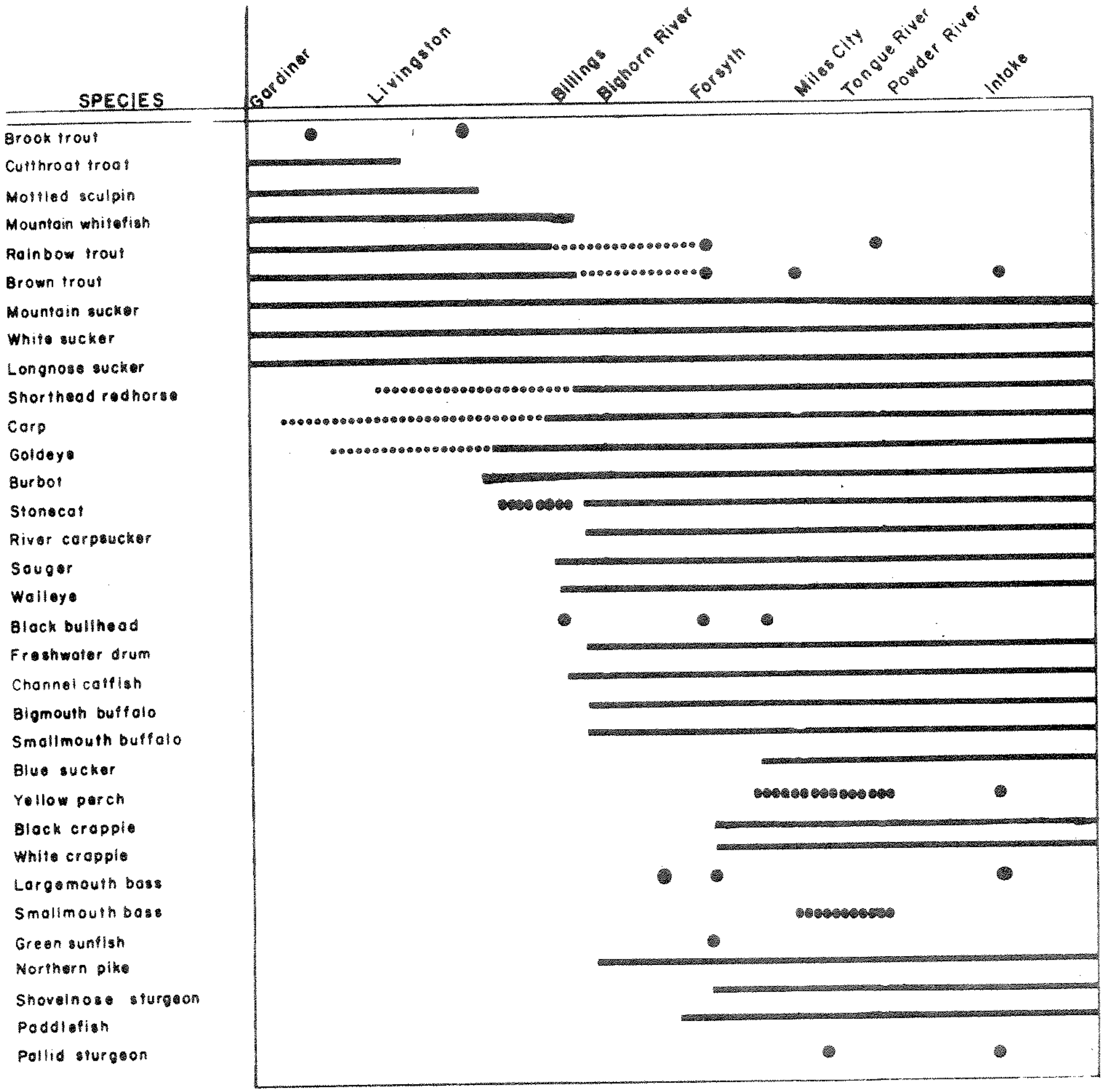


Figure 3. Longitudinal distributions of some fishes of the Yellowstone River of Montana.

Broken lines denote rare or occasional occurrence. Wide line indicates reproductive success in the area. Dots indicate occurrence of a single or a few individuals.

METHODS

To accomplish the objective, work is being directed toward (1) equipment development and sampling technique adaptation, (2) field life history studies of important fish species of the lower Yellowstone, and (3) predicting effects of proposed flow changes on important life history stages. Important fish species which are being studied include the channel catfish, sauger and walleye, burbot, shovelnose sturgeon and pallid sturgeon. Data were also collected on other species during general sampling surveys. Forage fish species were sampled, but have not yet been identified. A food habits study was initiated which will, when completed, identify forage fish species important to the major sport fish populations.

The prediction of impacts arising from potential water development projects on the Yellowstone requires a determination of the instream flow needs of the species of fish inhabiting the river. This, in turn, requires relatively complete knowledge of the life history of the species involved. It is unrealistic to assume that complete life histories of all species inhabiting the lower river will or can be determined; however, certain critical aspects (reproductive habits, habitat requirements, food habits and movements) of the life history of important sport species were studied. Once the physical needs of these species have been identified, the Bureau of Reclamation's Water Surface Profile Program will be used to relate the needs of these species to the computed channel and flow characteristics found at various flow levels.

Certain habitat types may be affected more severely than others by a chronic reduction in stage height of the river. Backwater habitat types fall in this category. Backwaters are areas that characteristically have slack or very slowly moving water and are generally formed from side channels when water levels decline after high water. Occasionally backwaters occur at the mouths of some tributary streams when the tributaries cease flowing in midsummer. Since the formation and maintenance of backwater areas are dependent on the stage heights of the river, a severe or long-term reduction in water level will eliminate or greatly reduce many of the present backwater areas.

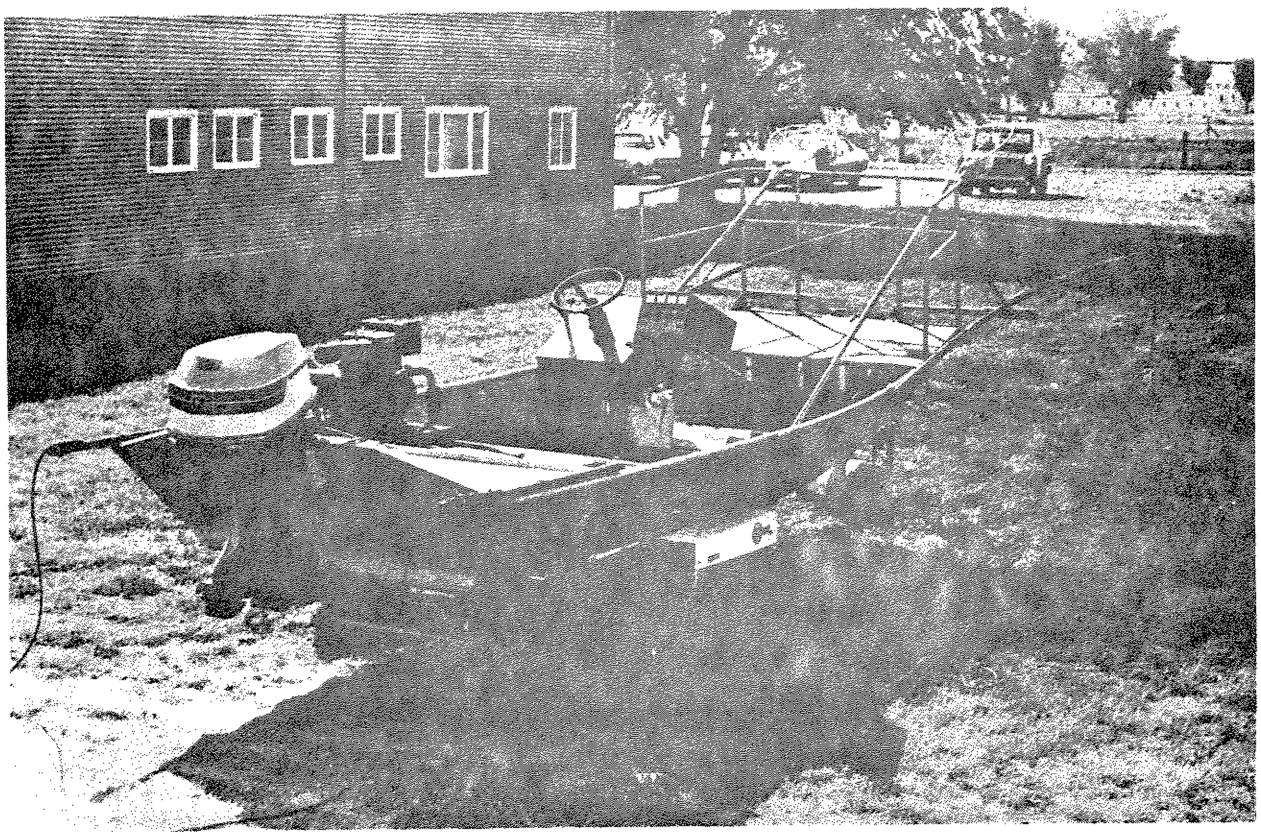
A long-term backwater study plan was designed to determine the importance to, and utilization of, backwater areas by the river fish populations. Principal areas of investigation include species utilization, seasonal utilization, reproduction and rearing, and forage fish production of backwater areas. To accomplish this, selected backwaters were sampled on a monthly basis by first isolating the backwater with block nets and then intensively electrofishing, seining and gill netting the area. Initial results indicated that during periods of increased fish activity, the sampling periodicity should be increased. Water quality and temperatures were monitored in backwaters under study and in adjacent main channel areas. Since this study is just beginning, initial data will not be presented at this time.

PRELIMINARY FINDINGS

Equipment Development and Sampling Technique Adaptation

The large size of the lower Yellowstone, combined with relatively high current velocities, seasonally turbid water conditions, and a large, diverse fish fauna present unique and extremely difficult sampling problems. Therefore, equipment development and sampling technique adaptation must necessarily precede any intensive life history investigations. Following is a discussion of the methods of capture employed during the past year, the comparative effectiveness of the methods, and their limitations.

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 involves a variety of fixed positive and negative electrode arrangements suspended from fiberglass booms fastened to the front of the boat. The power source is a 4500 watt AC generator and is ample for the electrofishing apparatus and supplemental lighting equipment for night shocking. Voltage and amperage regulation from the power source to the water is through a Coffelt Variable Voltage Pulsator model VVP-10. This electrofishing unit offers output voltages of 0 to 300 volts with AC, DC, or pulsed DC current at 0 to 25 amps. The capacity of the unit is 10,000 watts. The proper current type, voltage, amperage and electrode arrangement for efficient capture of fish in the lower river is still in the experimental stage and depends on the fish species desired, water temperature, conductivity, and turbidity conditions.

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 the deeper 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 electrotetanus or simple immobilization of fish. 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. Therefore, the present AC system is valuable only during relatively clear water conditions. Under clear water conditions 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, white and blue suckers, carp, goldeye, river carpsucker and both bigmouth and smallmouth buffalo. It was effective on channel catfish only in shallow, clear water. It was not effective in capturing northern pike, burbot or shovelnose sturgeon.

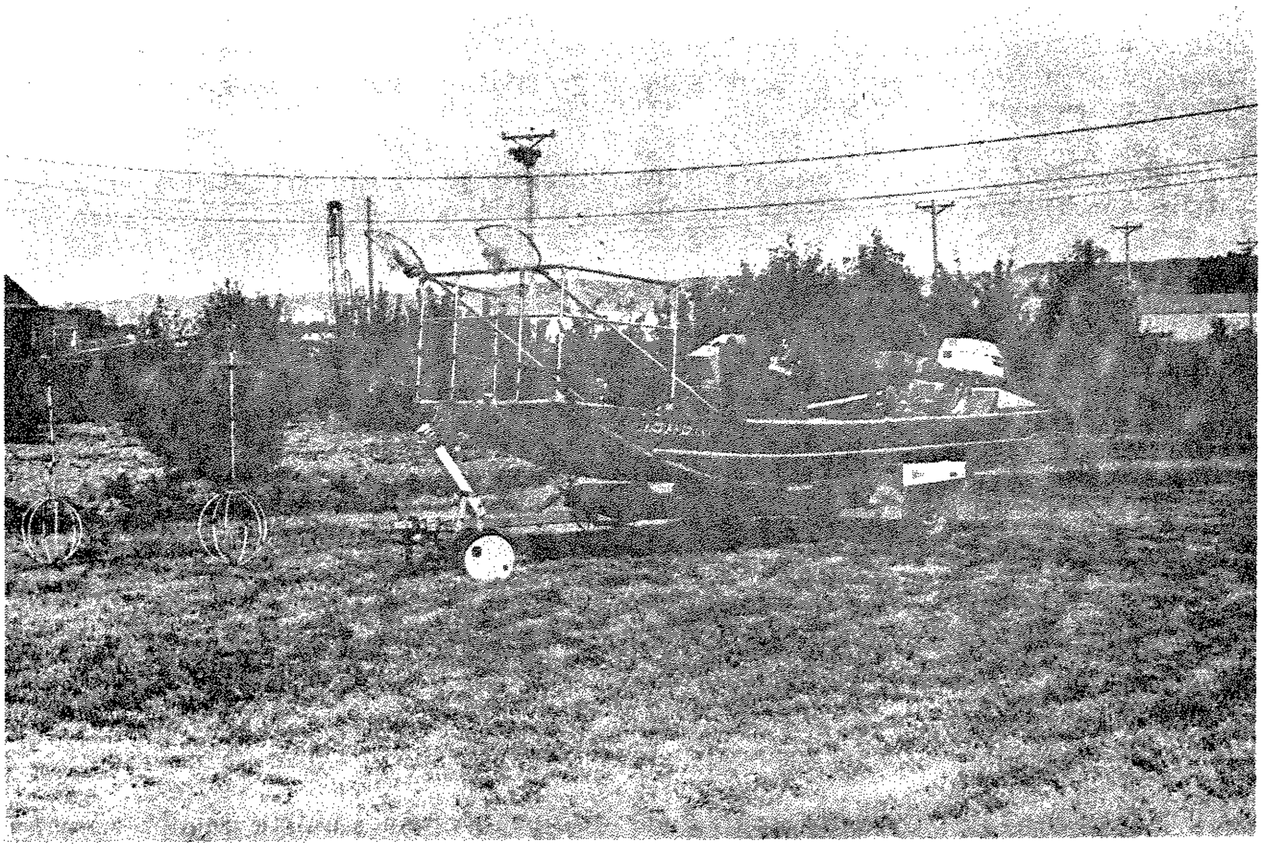
The AC electrode system was tested in an area of known paddlefish concentrations (below Intake). Paddlefish are easily seen when within the electrical field; however, their strong swimming ability enables them to escape the field when water depths exceed 4 to 5 feet. Paddlefish can be stunned and netted in shallow areas, but the problem then becomes having adequate live tank storage capacity in the boat to hold these large fish.

A primary use of AC electrofishing for paddlefish may lie in determining presence or absence of paddlefish in tributaries during the spawning season, use of the side channel around the Intake diversion for migration, and timing and extent of the spring paddlefish migration. These factors can be determined simply by observing the paddlefish, not necessarily netting them. Additional experimentation with AC systems will involve alternate polarity and multiple pairs electrode array systems described by Novotony and Priegel (1974).

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

In a DC or pulsed DC current system, fish in the field respond by swimming toward the anode (electrotaxis). With the anode 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 since this combines, 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 response to pulsed DC current. In addition, burbot and shovelnose sturgeon exhibited much better response and were much easier to net with



pulsed DC than with AC. Paddlefish, on the other hand, were less susceptible to pulsed DC. Too few channel catfish were captured during the DC sampling to make any qualitative judgment on either susceptibility or response.

Future research in DC electrofishing will involve electrode shape and size and construction of dropper electrodes suspended from aluminum rings as described by Novotony and Priegel (1974). In addition, the DC electrofishing unit has yet to be tested under clear water conditions in the Yellowstone.

A third type of electrofishing unit was used on the lower 20 miles of the Tongue River and on small side channels and specific habitat types on the Yellowstone. This unit consisted of a 14-foot fiberglass boat with a hand-held mobile positive electrode unit as described by Vincent (1971). Power was supplied from a 2,500 watt AC generator and converted to DC, full-pulsed DC, or half-pulsed DC through a Fisher Shocker Model FS-103 (capacity 1200 watts). This unit allows greater maneuverability in restricted channel areas and a more efficient probing of selected habitat types (riprap, log jams, etc.) for small fish; however, the effective area around the electrode is quite small.

The mobile electrode unit was effective in capturing sauger, walleye, channel catfish, and a variety of nongame species in the lower Tongue under clear water conditions during early spring 1974. In late spring, when water conditions became very turbid, this unit lost much of its effectiveness. Sauger, walleye and channel catfish were most effectively captured in the lower Tongue using half-pulsed DC output of 5 to 6 amps and 150 to 200 volts. This approaches the recommended maximum capacity of the Fisher Shocker model FS-103 and limits the effectiveness of this unit under certain water conditions.

The mobile electrode unit was almost totally ineffective for any sampling of main channel areas of the lower Yellowstone River. Its chief value on the mainstem of the Yellowstone lies in its ability to probe rock riprap, brush piles and other confined habitat areas in search of forage fish and age 0 sport fish.

Gill Nets

Gill nets are a valuable fish sampling tool on the lower river; however, they can be set stationary (dead set) only in backwater areas, off of 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 are standard experimental sinking nets, 125 feet in length, 6 feet deep, with graduated mesh size of 3/4 to 2-inch square measure. Dead set gill nets are effective for capturing a wide variety of fish species, but their usefulness for gathering complete distribution data is limited, since they sample a limited number of habitat types.

Large mesh (2-1/2 to 4-inch square measure) 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 is quite selective for shovelnose, which composed 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. There is undoubtedly selection for larger fish using this technique, but the sharp and angular nature of the five rows of bony scutes found on the shovelnose do cause many of the smaller individuals to also become entangled.

Several other species were also commonly captured using this technique. Channel catfish and blue suckers were frequently 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 fish was captured. It is felt that a 6-inch mesh (square measure) may be more effective on paddlefish, and this technique shows promise of obtaining paddlefish samples in areas of the river other than where fishermen traditionally congregate.

Fish Tags

A variety of individually numbered tags were experimentally used on a number of fish species during the past year. The selection of a specific type of tag for each species involves an analysis of the permanence of the tag, the mortality caused by the tag or tagging procedure, and any behavioral aberrations caused by the tag or its application. This study has not been in progress long enough to adequately analyze these factors, but much information was obtained from literature and correspondence with other state fishery departments involved in similar research.

Numbered fish tags are valuable in monitoring movement patterns of individual fish and establishing home ranges. Fish marked during spawning migrations or at spawning areas and recaptured later provide information on distances traveled to reach the spawning site and the importance of specific spawning areas to downstream reaches of the Yellowstone. This 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 fisherman harvest rates.

Shovelnose sturgeon were tagged using individually numbered #3 monel metal tags clipped to the pectoral fin near the body (Schmulbach 1974). This tag showed good retention on the fish but it was slow to put on larger fish and scar tissue grew over the tag, at times covering it completely. Numbered Floy T-tags were also used on some sturgeon and placed directly behind the dorsal fin; however, tag retention and mortality by this method is 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 tags were also anchored through the pectoral girdle dorsal to the fin, but tag loss by this method is also a serious problem (Helm 1974).

Channel catfish were tagged using numbered Floy tags anchored near the base of the dorsal fin. Recaptured fish indicated a significant tag loss using this method. Future tagging of channel catfish will follow the method described by Pelgen and McCammon (1955). This method involves fastening a round, numbered plastic tag to the body posterior to the dorsal fin with 0.032-inch diameter stainless steel wire. Preliminary tagging studies in Nebraska (Q. Bliss - pers. comm.) indicate little chance of tag loss using this method.

Individually numbered Floy tags were used on sauger, walleye, northern pike, blue sucker, bigmouth and smallmouth buffalo and burbot. These tags were anchored near the base of the dorsal fin. No tag loss was noticed on sauger, so this method will be used for future studies. Insufficient recaptures were obtained for an analysis of tag retention on the other species mentioned above.

Future Areas of Research

Much research remains to be done in the area of equipment development and sampling technique adaptation on the lower Yellowstone. Several species of fish remain difficult to capture in main channel areas of the river, while others are captured only seasonally. Northern pike are readily captured in gill nets in backwater areas; however, they respond poorly to electrofishing in main channel areas. Pallid sturgeon are rare in the lower Yellowstone and adequate sample sizes for life history studies are, at present, impossible to obtain. In addition, all fish species are difficult to sample in certain areas of the main channel, such as deep pools and runs.

Little information is available on winter sampling techniques for large river systems, but the winter period is historically the period of lowest flows and the aquatic populations are probably under their greatest period of stress and suffer the highest natural mortality. When considering the effects of chronic, yearlong dewatering, it is imperative to obtain at least movement and habitat data through the mid-winter period.

Future research in equipment development and sampling technique adaptation includes refining techniques already in use for greater capture rates and developing new techniques for sampling fish species and habitat areas not presently being sampled. Work will be directed toward trap net modification for backwater areas, fyke nets for channel catfish in main channel areas, and adaptation of beach seine and trip line seine for main channel areas.

The Department of Fish and Game, in conjunction with Coffelt Electronics, Inc., will field test a Rotating Field electrofishing unit on the Yellowstone with the hope of obtaining fish samples from deep pool areas of the river. Work will continue on improving techniques for capturing age 0 sport species for determining growth rates and habitat preferences. Winter sampling will be attempted in the coming year.

Field Life History Studies

Shovelnose Sturgeon

The shovelnose sturgeon descended from a primitive group of bony fishes (subclass Palaeopteryii) which was dominant during the Palaeozoic era. The living descendants of this group found in the lower Yellowstone include the paddlefish, pallid sturgeon and 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 where shovelnose are found which has not been significantly altered by dam construction and/or channelization and offers 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 has been taken at the mouth of the Tongue River and below the Intake diversion structure at Intake. Seldom are more than one to three pallid sturgeon reported from the Yellowstone annually.)

The shovelnose sturgeon is a popular sport species in the lower Yellowstone. It has been 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. 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 seasonally during the spring high water period.

Investigations into the distribution and life history of the shovelnose sturgeon were initiated in April of 1974. Since only one year's data are available, no firm conclusions can be drawn at this time; however, preliminary findings will be presented here.

Distribution in Yellowstone River

The shovelnose sturgeon is 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 were 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.

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 spawning run from the Yellowstone into the lower 20 miles of the Tongue River was documented and monitored. During the period from April 24 to July 8, 1974, 427 shovelnose were captured in the lower Tongue. Four hundred twenty of these 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, sizable numbers 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 last sampling occurred on July 8, and resulted in a catch of 20 shovelnose. Sturgeon were probably present in the Tongue for a longer period.

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 and one ripe, partially spent female was captured on June 4. Future research will be aimed at determining exact spawning times, locations, water conditions and capture of larval shovelnose. The relationship between the shovelnose spawning run and the temperature and flow regimens of the lower Tongue are presented in Figures 4 and 5, respectively.

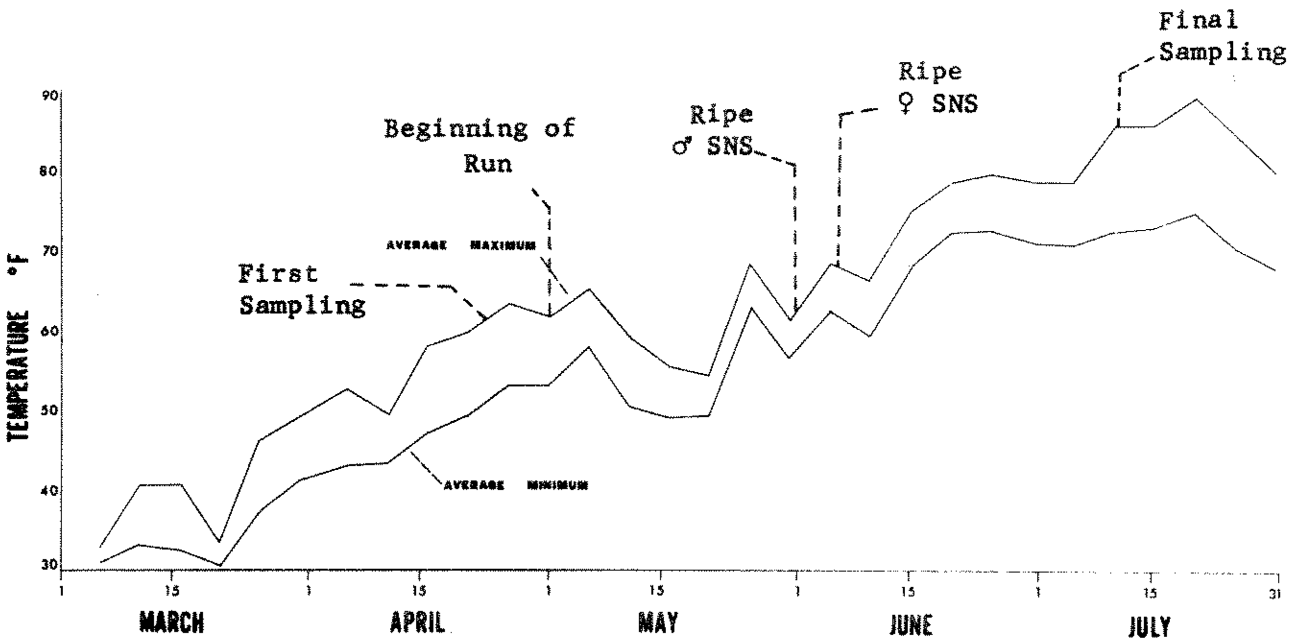


Figure 4. Relationship of shovelnose sturgeon (SNS) spawning run and the average 5-day maximum-minimum temperature regimen of the lower Tongue River during spring and summer 1974.

Limited sampling indicates that shovelnose sturgeon apparently migrate from the Yellowstone into the Powder River during the spawning season. One sturgeon tagged in the Yellowstone at Forsyth (April 1974) was recaptured in the Powder River, approximately 2 miles above its mouth, during June 1975. Extreme turbidity conditions (4,000 JTU) severely hampered sampling efforts in the Powder and prevented an adequate assessment of the run.

Length and Weight Comparisons

The average fork length of 427 shovelnose captured during this period in the Tongue 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 of more, 11 percent weighed 8 pounds or more and 5 percent weighed 10 pounds of more (Figure 6). (Verification of identification of larger specimens by Dr. W. Gould, Assistant Leader, Cooperative Fisheries Unit, Montana State University).

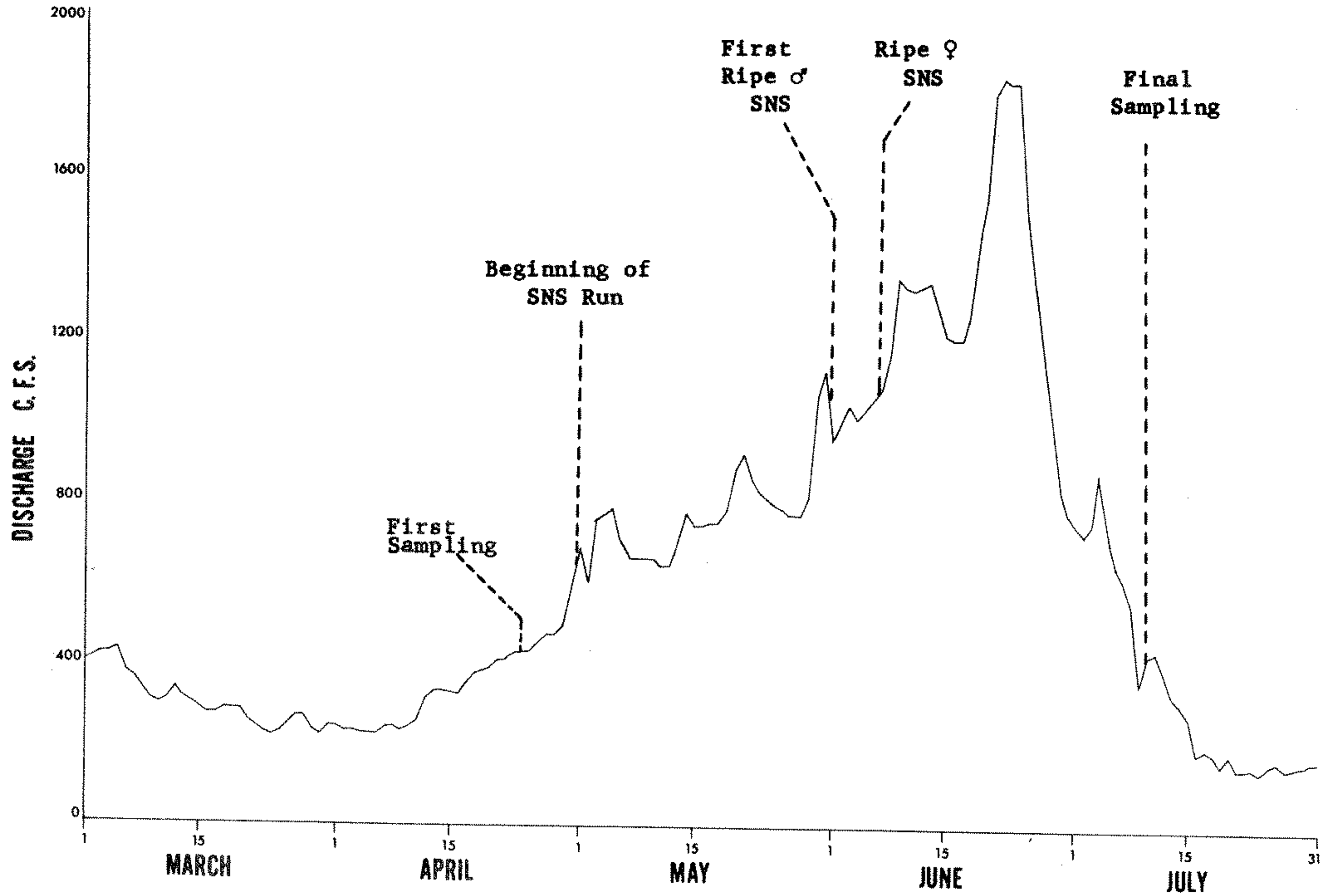


Figure 5. Relationship between shovelnose sturgeon (SNS) spawning run and discharge of the Tongue River during spring and summer 1974.

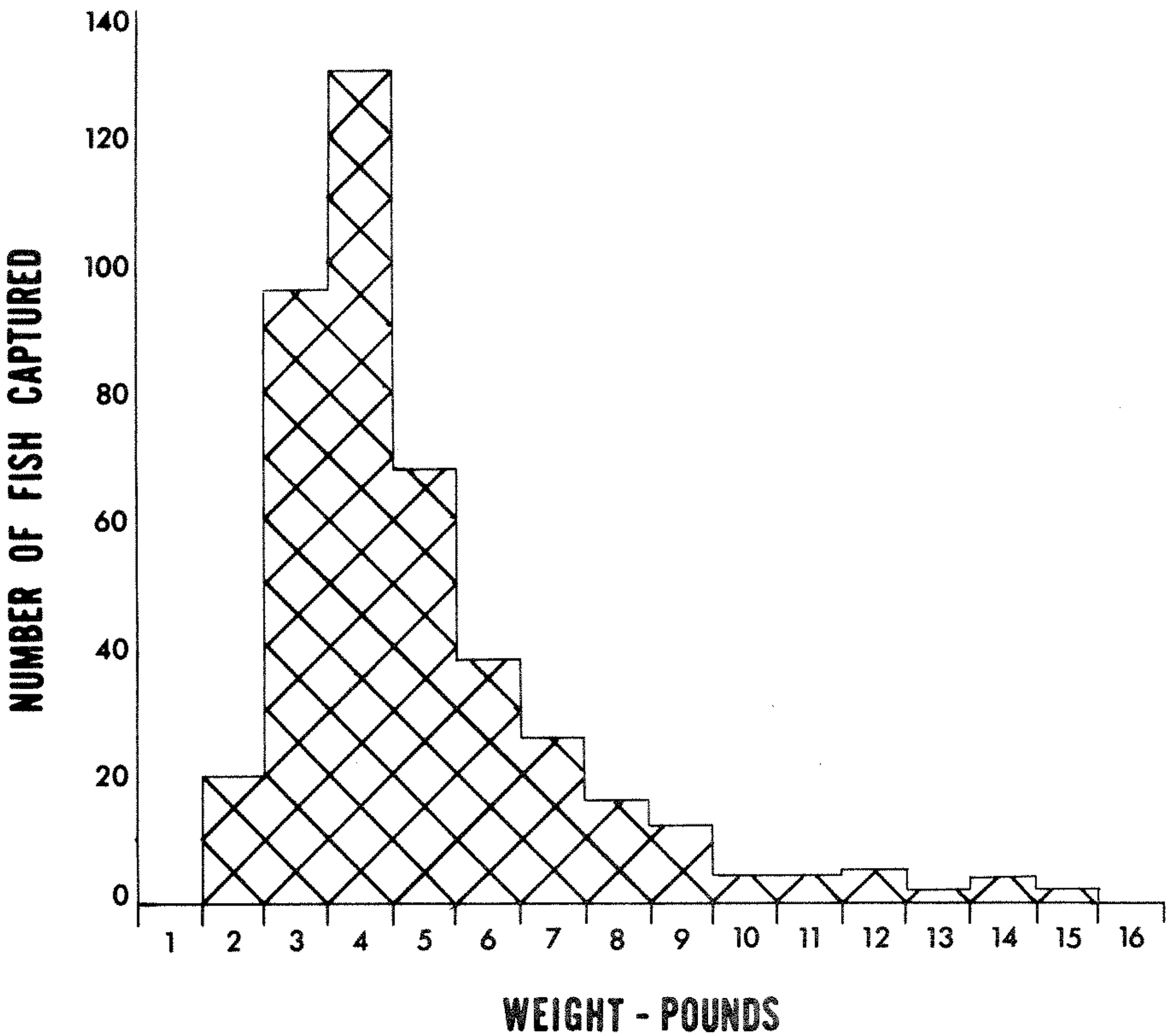


Figure 6. Weight - frequency of 427 shovelnose sturgeon captured in the lower Tongue River from April 24 to July 8, 1974.

These fish are significantly larger than shovelnose reported elsewhere in the Missouri-Mississippi River drainage. Out 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 pers. comm.). On the Mississippi River bordering Iowa, Helms (1974) reported that 60 percent of 5,204 commercially harvested shovelnose weighed between 1-2 pounds. The record shovelnose for Iowa came from the Des Moines River and weighed 12 pounds (D. Helms pers. comm.). The size difference between Mississippi and Missouri River shovelnose is not directly comparable, since the Tongue River sample came from a suspected spawning run and a larger average size would be expected from mature adult fish than from samples taken randomly from the entire population. Nevertheless, the number of fish captured in the Tongue which were larger than the maximum size reported for the two other areas is 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 at Intake (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 2-1/2 to 3-1/2 inch mesh 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. It was felt that electrofishing would yield a more representative sample of the sturgeon population, since the large mesh gill nets seldom captured sturgeon less than 1.5 pounds. A total of 102 shovelnose was 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, respectively. Fork length 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 pounds. Electrofishing with pulsed DC current apparently is a less selective method than drifting large mesh gill nets for sampling the shovelnose population.

It is interesting to note that electrofishing with pulsed DC current at Miles City and Forsyth failed to produce shovelnose less than 1.35 pounds. The same time period was involved and similar habitat types were sampled. This is in contrast to the section below the Intake diversion where shovelnose less than 1.0 pounds are readily captured with pulsed DC current. Future research will be aimed at providing a satisfactory explanation of this phenomenon.

Sauger and Walleye

The sauger and walleye are two of the most important sportfish in the lower Yellowstone River. These two similar species are usually lumped together by fishermen and are commonly referred to as sand pike and pike. The most popular and productive areas for sauger and walleye angling are below the low head irrigation diversion structures in the lower river, such as 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. A significant sauger fishery occurs in the lower Tongue River. The best angling seems to take place during early spring before high water and later in the summer after high water when the river begins to clear.

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 (1803-1806). 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 much 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 data may be due to the difficulties in sampling large flowing waters, and the relatively low population densities which may occur in such environments. There is considerably more data available related to the sauger and walleye in lentic environments. This is no doubt due to their dominance in such waters and their importance to the sport and commercial fishery in many areas.

During 1973 and 1974, studies were initiated to gather certain life history data on the sauger and walleye populations of the Yellowstone as well as information on distribution and abundance. Other objectives were to develop effective sampling methods for these species in a river environment and define the physical features of the river necessary to maintain existing sauger and walleye populations.

Gill Net Survey

Gill nets were used primarily in the fall of 1973 to inventory and define the distribution of sauger and walleye. Electrofishing with AC current was used to capture sauger and walleye in a 1-mile section of river below the irrigation diversion structure at Forsyth during the spring and fall of 1974. From September through November of 1973, five areas of the lower Yellowstone were sampled using 125-foot experimental gill nets. The five areas of the river sampled were in the vicinity of 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). Sauger were taken at all these locations. Catch rates for 18-hour overnight gill nets set in the five areas ranged from a low of 1.13 at Myers to a high of 3.83 at Terry (Table 5).

Table 5. Catch rate and size of sauger taken in gill nets from five areas of the lower Yellowstone River during the fall (September-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/ Number in parenthesis equals number of net sets

A total of 171 sauger was taken in 89 overnight nets set for a combined catch rate of 1.92 sauger per net set. Average size of these Yellowstone River sauger are comparable to those reported by Posewitz (1963) for the Missouri River and tributaries from Fort Peck reservoir to Morony dam.

A variety of habitat types was gill netted during this sampling period, including quiet waters and those associated with various current velocities. The lack of quiet water areas in the Terry area required all nets to be fished in areas with moderate current.

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 in an attempt to: (1) obtain a population estimate of sauger in this section, (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 (Table 6). A total of 430 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 marked sauger (6.4 percent) were recaptured by electrofishing (Table 7). No tagged walleye were recaptured during this sampling period.

The data in Table 7 were used with the Schnabel estimator to determine sauger numbers in the area during the sampling period (Chapman and Overton 1966).

Other sport fish in the section were not caught in large enough numbers for a population estimate. To allow a random distribution of tagged fish in the study section, no fish recaptured within 5 days after tagging were counted as recaptures.

Spawning runs of sauger and walleye in rivers have been documented by a number of workers including Morris (1964), Johnson and Johnson (1971), Madsen (1971), Crowe (1962), Schumacher (1965), and Olsen and Schidmore (1962). The sauger estimate was made on what is thought to be a spawning run and the possibility exists that new fish were continually entering the area; therefore, several conditions which Chapman and Overton (1966) believed necessary to make a valid estimate using the Schnabel estimator were not met. Ricker (1958), however, felt the estimator could still be useful, even though some conditions were not met.

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

Species	Number	Percent Total	Average Length	Range	Average Weight	Range
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 possible hybrid sauger x walleye

It was estimated that 2,024 sauger were present in this 1-mile section during the sampling period. Confidence intervals (Chapman and Overton 1966) at the 80 percent level were 1,564 to 2,867. Since certain basic assumptions in the use of the Schnabel estimator may not have been met, the numbers presented should not be construed as actual numbers present, but rather as an indicator of the magnitude of the sauger population. This will be used to compare the magnitude of the sauger population in future years in this location as well as comparing relative abundance between the Forsyth study section and other areas of the Yellowstone.

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

Date	Number Marked Per Run	Total Marked at Large	Number of Recaptures
4/ 5/74	-	-	-
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/ 2/74	3	57	-
5/ 7/74	54	111	2
5/ 8/74	32	143	3
5/ 9/74	30	173	2
5/13/74	44	217	4
5/14/74	16	233	4
5/16/74	29	262	1
5/20/74	33	295	2
Total	295		

Spawning

Sauger and walleye were apparently both spawning in the study section during the April and May 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 F 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 F to 52 F (Figure 7). Morris (1964) reported that sauger had not spawned in the Missouri River in Nebraska when water temperatures were 47 F. Johnson (1961) reported temperatures during walleye spawning periods in Lake Winnibigoshish, Minnesota, as between 41 F and 61 F with a daytime mean of 47 F during the 20-24 day incubation period. Nelson (1965) reported sauger spawning in Lewis and Clark Lake, South Dakota, to occur between April 27 and May 11. The peak of spawning occurred between April 29 and May 4, when water temperatures were 42-43 F. Priegel (1969) reported spawning in Lake Winnebago, Wisconsin to occur from May 2 to 9 when water temperatures ranged from 43-49 F. Eschmeyer and Smith (1943) reported sauger spawning did not take place in Norris Reservoir, Tennessee, when water temperatures were below 50 F.

Ripe sauger and walleye were commonly taken in water 1-4 feet deep with a sand or gravel bottom and a moderate current (Figure 8). Scott and Crossman (1973) reported similar spawning sites for the two species.

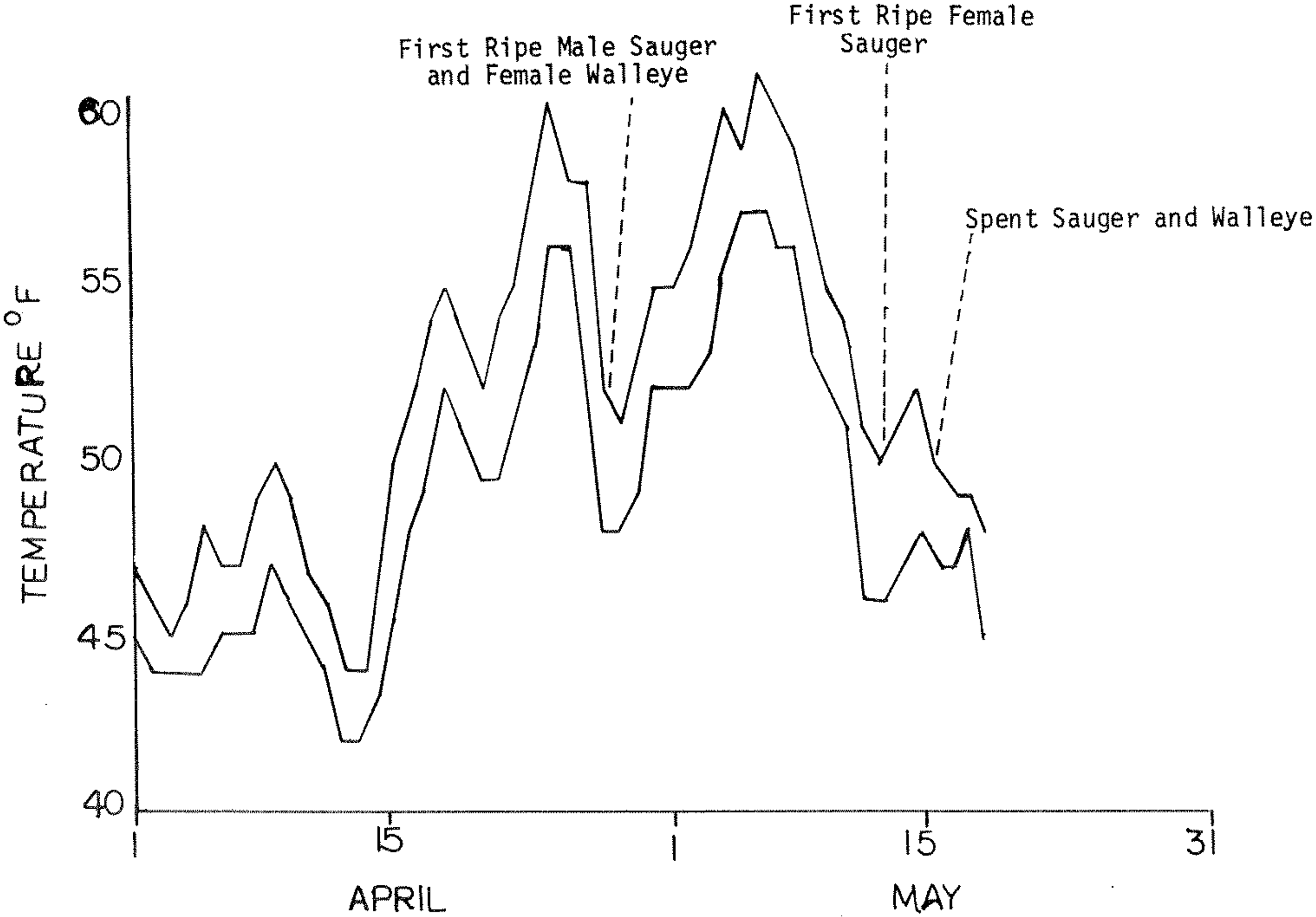


Figure 7. Daily maximum and minimum temperatures at Forsyth during April and May 1974, showing possible sauger and walleye spawning periods.

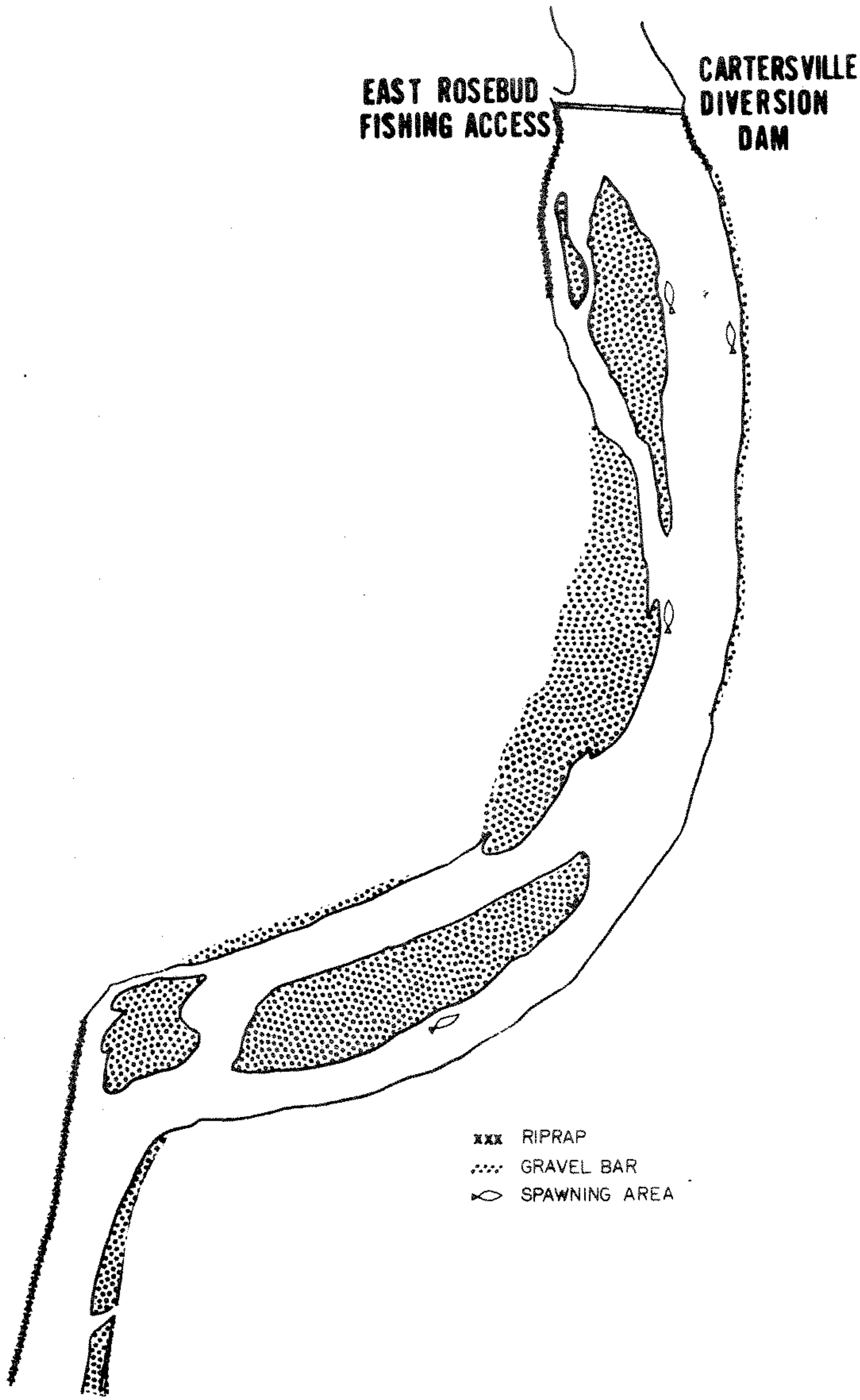


Figure 8. Probable sauger spawning areas in the Yellowstone River below the Cartersville diversion dam.

Johnson (1961) reported walleye spawning areas in a tributary of Lake Winnibigoshish as having gravel to sand bottom with water depths of 15-24 inches. He reported that they also preferred such areas in streams and lakes. Areas meeting these requirements are numerous in the lower Yellowstone and further investigations may locate abundant suitable spawning areas.

Age and Growth

Scale samples from 79 sauger collected in the study section below the Cartersville diversion during spring 1974 were used for age and growth determinations. These fish were taken by electrofishing and ranged in length from 9.7-20.7 inches. Age and growth data from those samples are presented in Table 8. Average annual growth rates for ages I through VII was 2.1 inches. Age and growth data for other sauger populations in Montana are presented in Table 9. Carufel (1963) reported similar growth rates for sauger from the Garrison reservoir tailrace, (2.26 inches), but average annual growth rates for sauger from Garrison reservoir were somewhat higher (3.07 inches).

Table 8. 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

Table 9. Age and growth of sauger from several locations in Montana (data from Peters 1964).

Location	Year Collected	Age Class I	II	III	IV	V	VI
Marias River	1961	4.4	8.0	11.1	13.2	15.1	18.3
Milk 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

Movements

Three hundred sauger over 10 inches total length captured by electrofishing at Forsyth (river mile 236-244) during April and May 1974 were tagged with individually numbered Floy tags. Twenty of these fish were returned over a 15-month period. Sixteen were returned by fishermen, providing a 6 percent angler return of marked fish, while four were recaptured while fishing at Forsyth and Miles City. Fishermen were advised of tagging operations by posters placed at all known fishing sites, sporting goods stores, bars, etc. and by news releases on radio and television.

Thirteen fish were recaptured within 1 mile of where they were tagged. Four fish exhibited extensive upstream movements which averaged 53.3 miles and ranged from 44 to 68 miles. Three fish exhibited extensive downstream movements which averaged 53.0 miles (Figure 9).

Thirteen walleye were also tagged in the Forsyth area during the same period. The only tag returned came from the same location, 14 months later.

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 Gavins Point dam on the Missouri River, Nebraska.

Movements of the walleye have been rather extensively studied, particularly those associated with spawning. Rawson (1956), and Smith et al. (1951) reported spawning runs of walleye from lakes to tributary streams, and Crowe (1962) 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 from 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 late evening, corresponding to the burbot's feeding habits, and only an occasional burbot is caught during daylight. Good catches are made by anglers from late February through early April.

In spite of its popularity, the burbot was only recently (1975 legislative session) classified as a game fish, and 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 initially were 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.

Four methods were used to capture burbot below the Cartersville diversion structure during late winter and early spring of 1974. These included: (1) angling with rod and reel and set lines, (2) hoopnets, (3) a boom electrofishing unit utilizing AC current, and (4) a mobile electrode unit utilizing DC current.

Angling at night with live minnows proved to be the most successful means of collecting burbot during March and April, just after ice out.

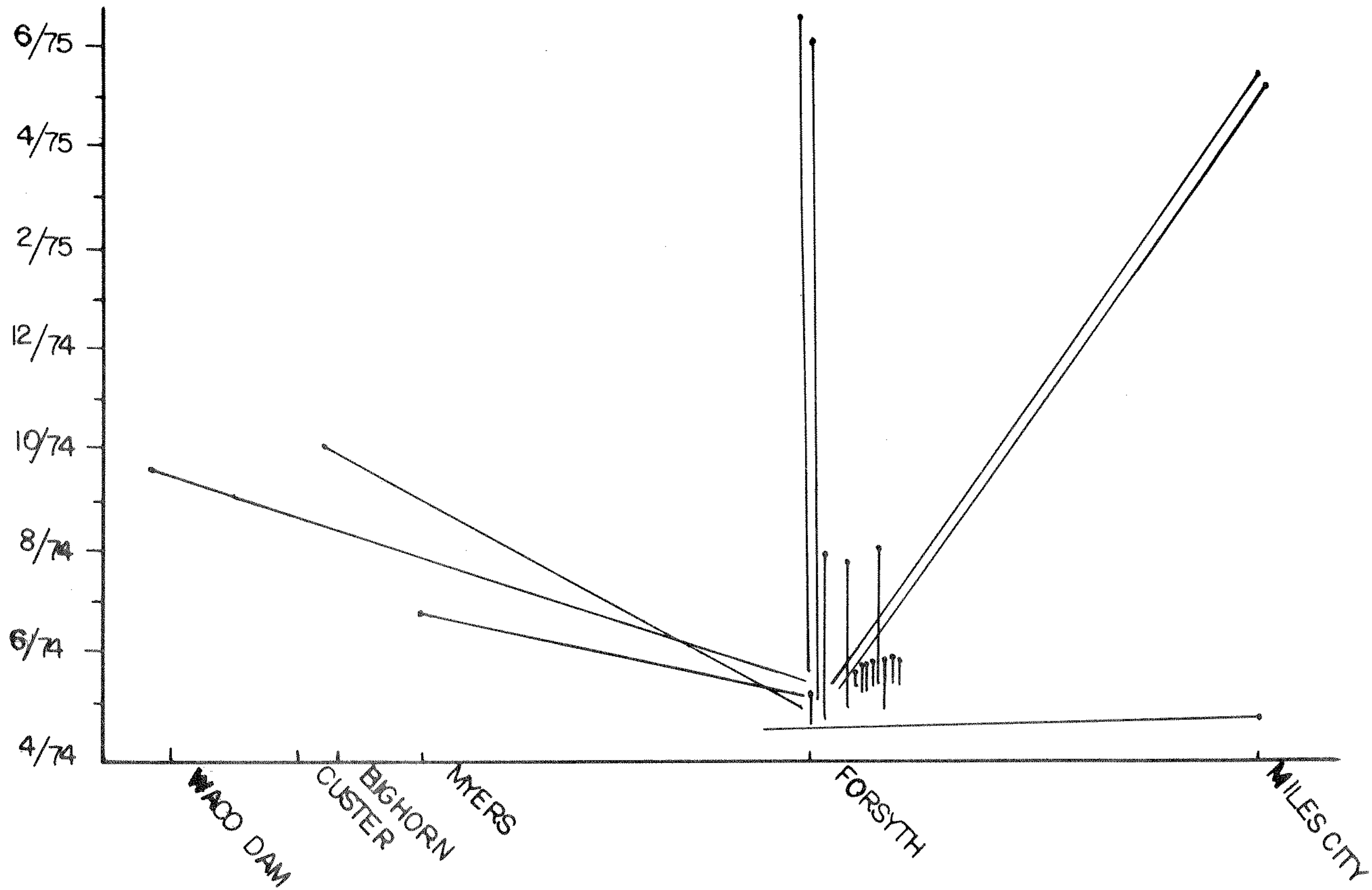


Figure 9. Movement of sauger tagged in the Yellowstone River near Forsyth during April and May 1974.

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 the 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 June of 1975 (Methods section). Under warm water conditions (greater than 50 F), burbot exhibited much better response to pulsed DC than to AC, and were easily seen and netted. This system will be tested next spring below the Cartersville diversion under cold water conditions.

Burbot Catch Statistics

Burbot were collected by department personnel during late winter and spring of 1974 by angling, set lines and electrofishing below the Cartersville diversion dam at the East Rosebud fishing access site. In 1975, angling was the only method employed. Average lengths, weights and ranges are presented in Table 10.

Table 10. 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

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 and length of trip and number of fish caught were recorded. In addition, in 1975 all 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 the fish 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 11. 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 4, 1975. The data presented in Table 11 are not meant to represent total harvest or total fishing pressure for the time period involved, nor can this information be determined from the data available.

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 12). 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 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 vary greatly (Carlander 1969).

Table 12. 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

Table 11. 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/ 3/75	3	9.00	32	3.56	16.0	10.0 - 28.0
3/ 4/75	3	8.25	31	3.76	15.7	10.0 - 27.0
3/ 8/75	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

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), Bonde 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 1.3-2.5 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 Lindsey 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 about February 10 in Burntside Lake, Minnesota, between 1931 and 1936 (Cahn 1936). These times approximate spawning periods reported for other populations (Verg 1949, Hewson 1955, Miller 1970a).

Burbot are reported to spawn both in lakes and streams. McCrimmon (1959) found that the majority of fish in Lake Simcoe, Ontario, spawned in the open lake, although some possibly spawned in rivers. In Lake Simcoe, fish congregated on a shoal 3-15 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 1-4 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 about 1/2 mile above the lake. The location of specific burbot spawning sites in the lower Yellowstone will be difficult, since severe ice conditions and fluctuating water levels occur during the probable spawning period of January and February.

Movements

A total of 60 fish was tagged during the spring of 1974 using individually numbered Floy tags. Floy tags were inserted behind the second dorsal fin on fish larger than 12 inches, and through the fleshy portion of the tail just anterior to the caudal fin on fish smaller than 12 inches. Fish caught by anglers were tagged and held overnight in live cars prior to being released to evaluate mortalities.

No tagged burbot were recaptured during the report period, which undoubtedly reflects the small number of fish marked. A comprehensive movement evaluation must necessarily await the development of effective sampling techniques for burbot where large numbers of fish can be easily captured and tagged.

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 of the lower Yellowstone, and, based on warden creel checks, make up about 25 percent of the fishermen'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 of 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. Since large areas of the main channel were not sampled, gill net data are of limited value in determining habitat preferences. Baited hoop nets set in main channel areas were largely unsuccessful. The lack of success was probably related to the type and location of set rather than to the efficiency of the hoop nets, since other workers report good success with baited hoop nets in large rivers (VanEeckhout 1974, C. Wallace pers. comm.).

Catch Statistics

A number of channel catfish were taken while sampling for other species during electrofishing operations. The use of electrofishing is apparently very selective for large fish. A total of 42 channel catfish was taken by electrofishing below the Cartersville diversion dam at Forsyth during April and May 1974. These fish averaged 19.7 inches in length and 3.6 pounds in weight, which was larger than those taken by gill nets (Table 13).

Eighty-nine gill net sets were made in the Yellowstone at five locations: Hysham, Forsyth, Miles City, Terry and Intake, between August and November of 1973. A total of 383 channel catfish was taken (Table 13).

Table 13. Number and size of channel catfish taken in gill nets from the Yellowstone River during fall 1973.

Location	Number Net Sets	Number Fish Taken	Ave. No. Fish per Net	Ave. Length	Range	Ave. 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)

Average catch rates for channel catfish from these gill net sets decreased downstream to the Terry sampling area, and then increased in the Intake sampling section (see Table 13). 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 late 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 14).

Table 14. 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	Ave. No. Fish per Net	Total No. Fish Taken	Number Net Sets	Ave. 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 decreases 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. The low catch rate of channel catfish in the Terry section may reflect 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.

Spawning

The increased utilization of backwater areas during late summer may be related to physical conditions required for spawning. Temperature data for the Yellowstone at Forsyth, Miles City and Glendive, show main channel temperatures seldom exceed 80 F, and reach and maintain 75 to 80 F only for short periods during late July and August. It is possible that during late summer, backwater areas are the only places in the Yellowstone which reach and maintain temperatures suitable for channel catfish spawning. VanEeckhout (1974) reported spawning in the Little Missouri River in North Dakota from mid-June to late July at temperatures between 70 F and 80 F. Miller (1966) reported optimum spawning temperatures at 80 F, with spawning occurring between 75 to 85 F.

Other physical features found in backwater areas which may be related to channel catfish spawning are suitable nest sites, such as 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 have some type of cover.

Nine gill nets were set overnight in two backwater areas near Hysham and Miles City during late August 1974. Eighty-two catfish were taken from these net sets and examined to determine their state of maturity. No females were near a ripe condition and the eggs were not fully developed. Females examined during September 1974 were still full of eggs and had not spawned. Extremely cool 1974 summer water temperatures in the Yellowstone may have resulted in very limited channel catfish reproduction in the mainstem.

Movements

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 movement of tagged channel catfish from the upper Mississippi River were random, but some fish moved at least as far as 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). VanEeckhout (1974) reported movements of channel catfish from Garrison Reservoir up the Little Missouri River, North Dakota.

One hundred and eighty-two channel catfish had been tagged in the Yellowstone as of October 1974. Only one tag has been returned from those fish. This fish was tagged on April 18, 1974 immediately below the Cartersville diversion dam at Forsyth and was caught by an angler at the mouth of the Bighorn River on September 14, 1974. This represents an upstream movement of 60 miles in 144 days.

During April and May 1974, 35 channel catfish were tagged in the Tongue River below the T and Y diversion dam, an impassible structure 20.4 miles upstream from the mouth. These fish were taken by electrofishing with a mobile electrode unit, and by drifting large mesh gill nets coincidental to sauger and shovelnose sturgeon sampling. The average length was 22.0 inches (range 11.7-30.6 inches) and average weight was 5.52 pounds (range 0.38-17.0 pounds). One fish tagged at river mile 20.0 (Tongue River) on April 30, 1974 was caught by an angler on July 7, 1974 at river mile 1.0 (Tongue River).

Three channel catfish tagged in the Little Missouri arm of Garrison reservoir, North Dakota, were caught in the Yellowstone River in Montana. One fish tagged in 1969 was caught in 1971 near Savage, Montana (river mile 60.0). Two fish tagged in 1971 were caught in the Yellowstone - one at the mouth (river mile 0) in 1972 and one near Glendive (river mile 92.0) in 1973 (VanEeckhout 1974).

Gill Net Survey, Fall 1973

During the period from late August to November of 1973, five areas of the lower Yellowstone were sampled using 125-foot experimental gill nets. The areas sampled were near Intake (river mile 71.0), Terry (river mile 138.0), Miles City (river mile 185.0), Forsyth (river mile 239.0) and Myers (river mile 284.0), with 11, 6, 33, 24 and 15 net sets fished in each area, respectively. The information obtained from these nets aided in defining the distribution of many of the fish species found in the lower Yellowstone.

Thirty-six hundred and seventy-eight fish of 23 species were taken in the 89 sets, for an average catch rate of 41.33 fish per net set. Goldeye were the predominant species and accounted for 69.5 percent of the total catch, with channel catfish, river carpsucker and sauger making up 10.4 percent, 6.7 percent and 4.7 percent of the total catch, respectively. A summary of the total catch for 89 sets is presented in Table 15. A summary of the gill net catch statistics for each sampling location is presented in Tables 1-5 in the Appendix.

Forage Fish

The maintenance of the piscivorous sport and nonsport fish populations of the lower Yellowstone depends on an adequate forage fish base. A forage fish is any fish that is utilized as a source of food by other fish.

Most members of the Cyprinidae (minnow) family found in the lower Yellowstone are probably used, to some extent, as forage. Other species,

Table 15. Summary of gill net survey on the lower Yellowstone River in the fall of 1973, expressed as number of fish per net set.

Species	Hysham Section	Forsyth Section	Miles City Section	Terry Section	Intake Section
Shovelnose sturgeon	-	-	-	0.17	0.82
Goldeye	41.86	19.17	29.12	49.67	19.18
Rainbow trout	-	-	-	0.17	-
Northern pike	-	0.04	0.06	-	0.36
Carp	0.87	1.21	0.52	0.33	0.45
Goldfish	-	-	0.03	-	-
Flathead chub	0.07	0.62	0.24	0.17	0.09
River carpsucker	3.53	3.25	2.03	3.83	2.18
Smallmouth buffalo	0.33	0.38	0.06	-	-
Shorthead redhorse	1.67	2.08	0.48	0.50	-
Longnose sucker	0.53	0.50	0.33	0.17	0.09
White sucker	0.40	0.38	0.18	0.67	0.09
Black bullhead	-	0.04	-	-	-
Channel catfish	7.13	5.00	3.70	1.33	2.36
Stonecat	0.20	0.17	0.06	-	0.18
Burbot	-	0.04	-	-	0.09
Smallmouth bass	-	-	0.03	-	-
White crappie	0.13	-	0.09	0.33	-
Black crappie	-	0.25	-	0.17	-
Yellow perch	-	0.21	-	-	-
Sauger	1.13	2.04	1.45	3.83	3.09
Walleye	0.13	-	-	0.17	0.09
Freshwater drum	-	-	0.09	-	-
Total	57.98	35.38	38.47	61.51	29.07

such as the stonecat, are commonly found in fish stomachs. In addition, age 0 fish of both sport and nonsport species may also be used as forage by adult fish.

Forage fish samples were taken in the vicinities of Forsyth, Miles City, and Glendive during the fall of 1974. The initial objectives of this sampling were to obtain a reference collection of forage fish species and their distribution and to develop effective sampling techniques for forage species. Any attempt to determine relative abundance of forage fish species between areas depends on development of a standard method for determining capture per unit of effort. If a standard method can be developed, then forage fish sampling sites will be established and sampled on a regular basis.

Backwater areas were effectively sampled for forage fish by seining with a 100-foot 1/4-inch mesh seine. In the coming year main channel areas will be sampled for forage fish by electrofishing with AC and DC current using both the boom and mobile electrode units in an effort to obtain a more complete forage fish listing and to identify habitat preferences.

Water Temperatures

Water temperatures are being monitored on a continuous basis during the ice-free months at four locations in the lower Yellowstone. These monitoring sites are Forsyth, Miles City, Glendive and Sidney. The Miles City thermograph is maintained and operated by the U. S. Geological Survey and the others are maintained by the Department of Fish and Game.

A summary of temperature data collected at these four sites during April through September 1974 is presented in Figures 1-4 in the Appendix.

Temperatures are also monitored at Livingston in the upper river and at Billings in the middle river. Additional thermographs will be installed from Gardiner downstream to the confluence with the Missouri River at 50-80 mile intervals to obtain a longitudinal temperature profile of the entire river.

Water Quality

A great deal of water quality monitoring is currently being done on the Yellowstone River. The variation in location of the monitoring sites is such that a comprehensive longitudinal water quality profile of the entire river cannot be constructed from the data.

The Montana Department of Health and Environmental Sciences and the Department of Fish and Game have initiated a series of water quality "runs" from Gardiner, Montana (river mile 557.7) to Cartwright, North Dakota (river mile 9.0). A water quality "run" consists of following a block or unit of water and monitoring water quality changes from the uppermost station downstream. Nineteen water quality stations were established on the Yellowstone and correspond to biological sampling sites for aquatic insects, periphyton and phytoplankton and, in some cases, fish.

The water quality runs are not set on a rigid time schedule, but are designed to gather data during critical flow periods (peak flow, low summer flow and low winter flow) and critical biological periods (spawning, incubation, etc.). Eight water quality runs are planned per year. Data will be presented when sufficient samples have been analyzed to provide a meaningful interpretation.

LITERATURE CITED

Berg, L. S. 1949. Freshwater fishes of the U.S.S.R. and adjacent countries. 4th ed. Zool. Inst. Alcod Nauk. USSR 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, Q. 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 Book, 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.

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

Crowe, W. R. 1962. Homing behavior in walleyes. Trans. Am. Fish. Soc. 91:350-354.

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

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, 68 pp.

__________. 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. 31 pp.

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

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

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

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.

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. 381 pp.

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. 93 pp.

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

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

__________. 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. 56 pp.

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 investigations 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 designs and operational guidelines to increase the effectiveness of boom shockers. Wisc. Dept. of Natl. Res. Tech. Bull. No. 73. 48 pp.

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, 76 pp.

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

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

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

Ricker, W. E. 1958. Handbook of computations for biological statistics of fish populations. Bull. 119 Fish. Res. Bd. of Canada. 300 pp.

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. 34 pp.

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

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

Scott, W. B. and E. J. Crossman. 1973. Freshwater fishes of Canada. Fish. Res. Bd. of Canada. Bull. 184. 966 pp.

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. 278 pp.

VanEeckhout, 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.

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	.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	tr1/	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
Northern pike	2	tr[1/]	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					

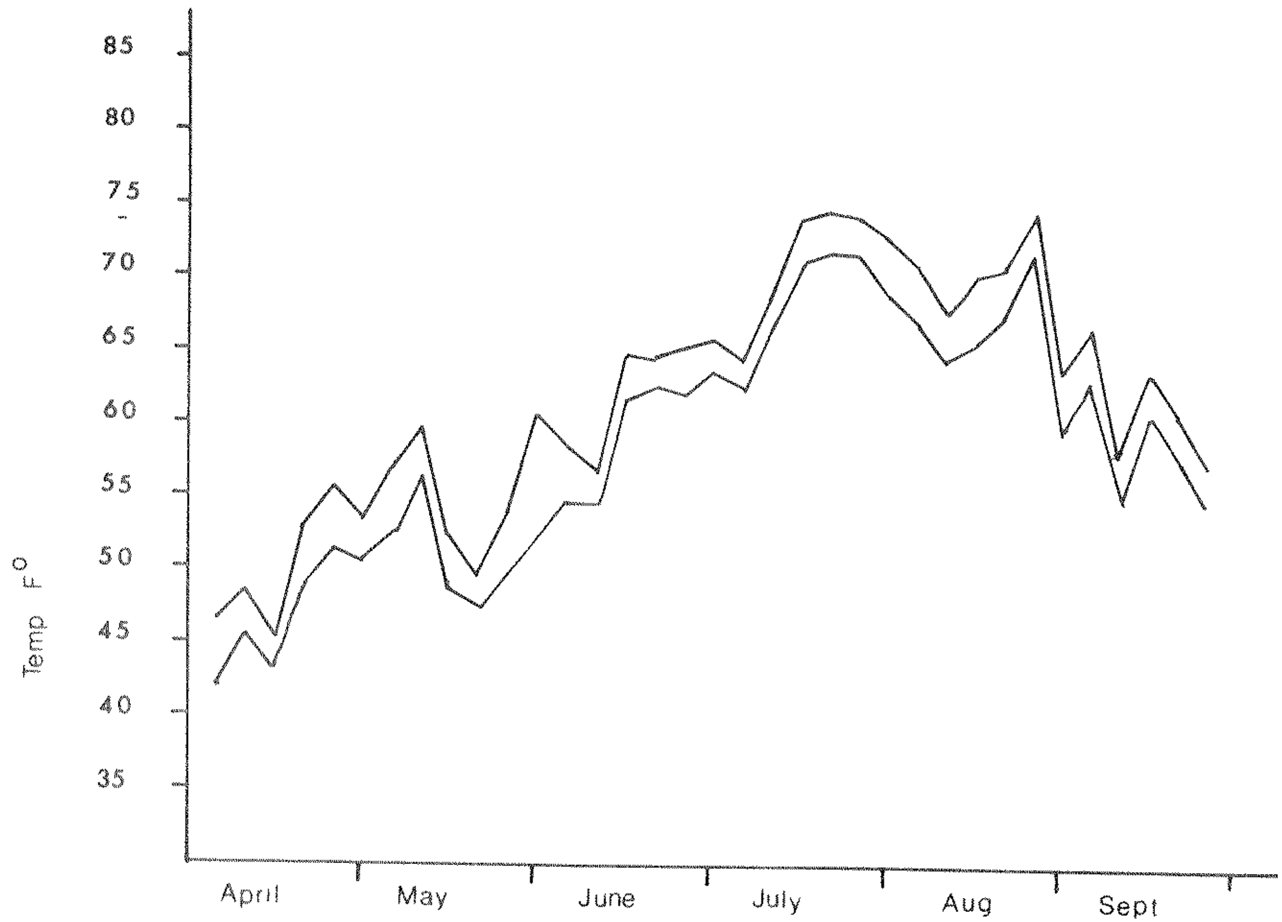


Figure 1. Five-day average maximum and minimum water temperatures for the Yellowstone River at Forsyth for the period April 1 - September 1974.

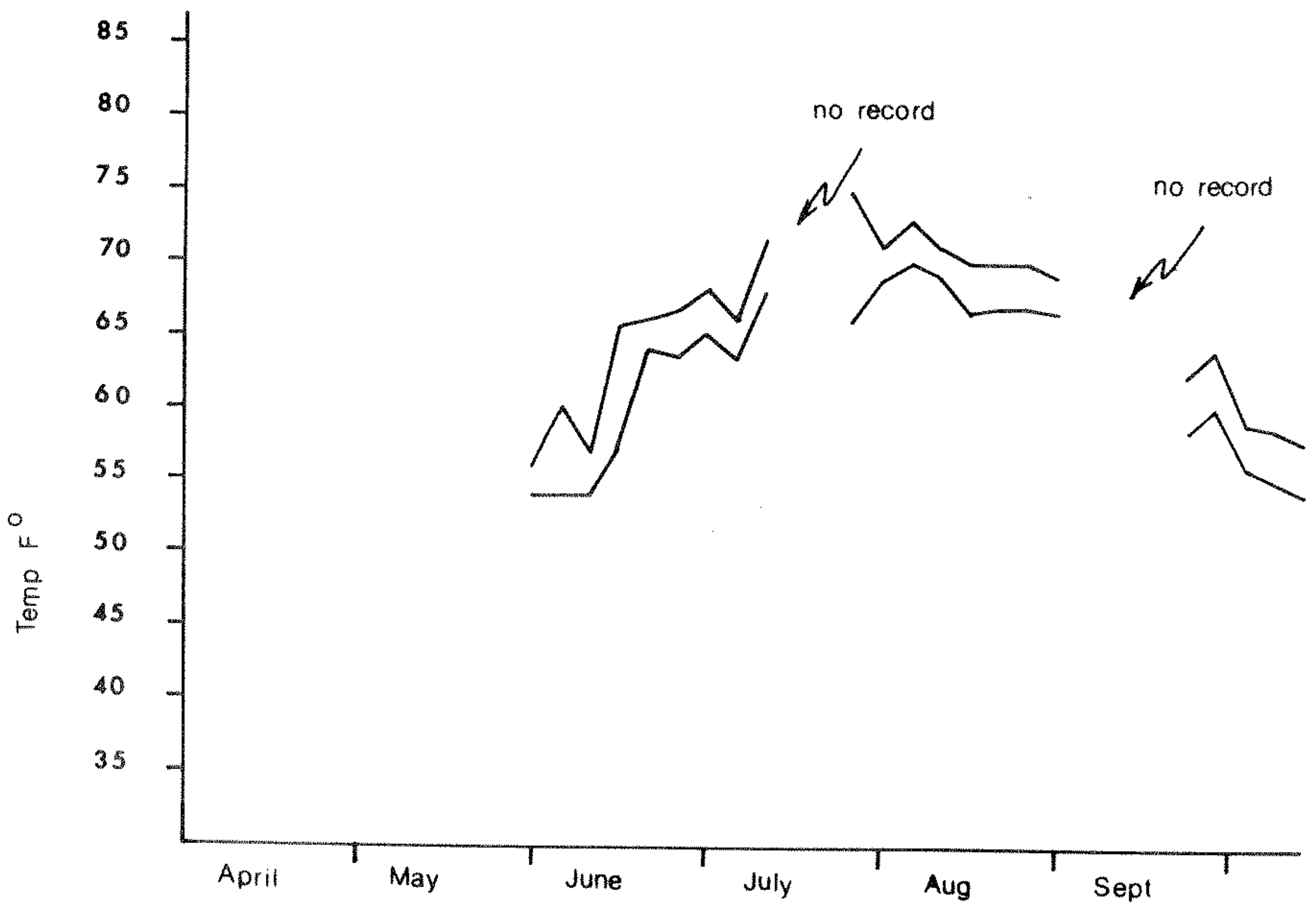


Figure 2. Five-day average maximum and minimum water temperature for the Yellowstone River at Miles City, May 25 - October 15, 1974 (USGS unpublished data).

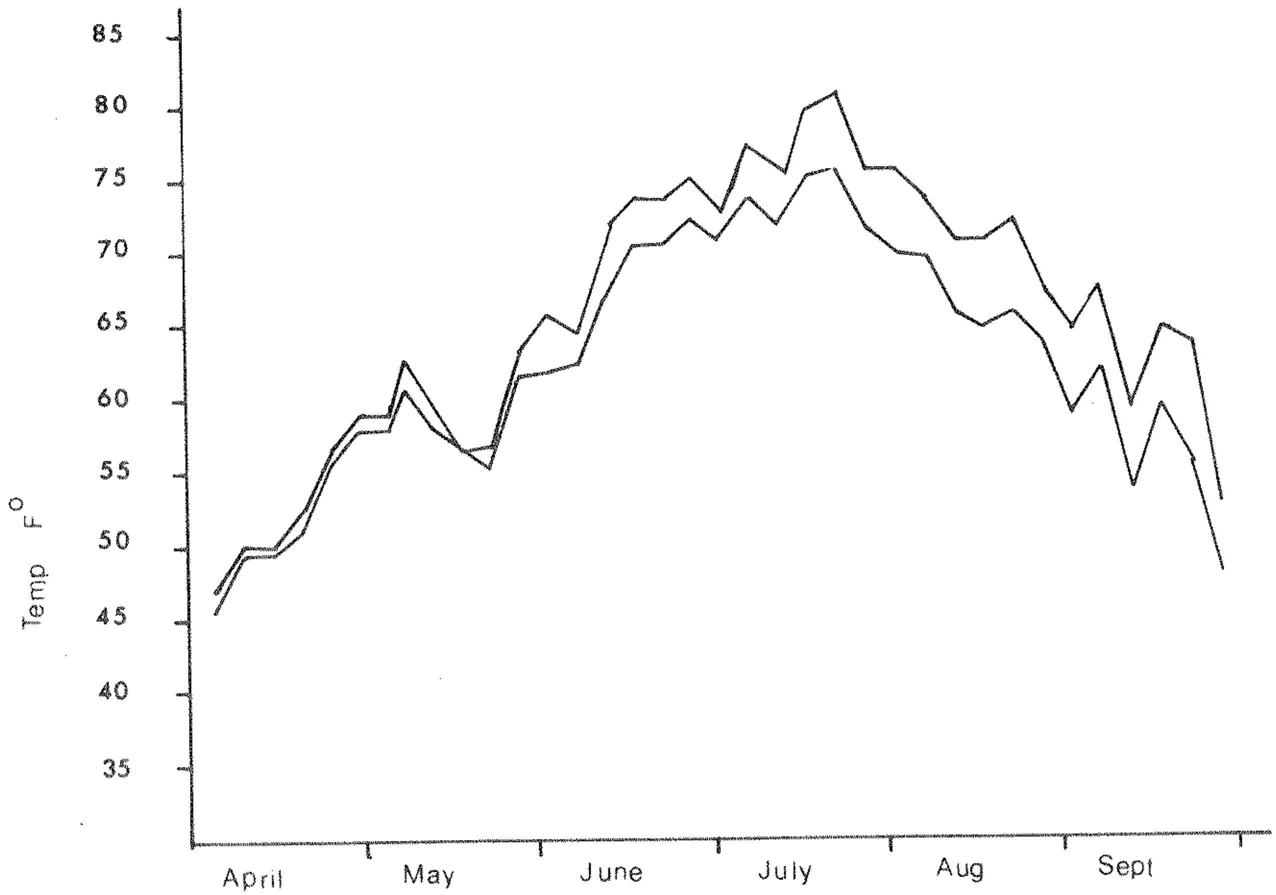


Figure 3. Five-day average maximum and minimum water temperatures for the Yellowstone River at Glendive, April 1 - September 30, 1974.