ASSESSMENT AND REQUIREMENTS OF SAUGER AND WALLEYE POPULATIONS IN THE LOWER YELLOWSTONE RIVER AND IT'S TRIBUTARIES

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ABSTRACT

This work is a compilation and extension of previous studies to quantify flow requirements, define fish life history and assess the impacts of energy development on the aquatic resource of the lower Yellowstone River and its tributaries.

Chronology of abundance of sauger, tag returns, and distribution of eggs and larvae show that the Tongue and Powder rivers are important spawning areas for this species in the Yellowstone River system. Little evidence was found of mainstem reproduction indicating that if these two tributaries are lost as spawning grounds sauger could be severely reduced in numbers in the Yellowstone River system. It was observed that 300 cfs was the critical low flow for sauger reproduction in the Tongue River. The allocated instream flow for the Tongue River is 75 cfs or 25 percent of the critical low flow. Water temperatures at peak sauger spawning ranged from 13 to 14°C.

Fifteen spawning areas for walleye were located in the Yellowstone from just upstream from Glendive (river km 163) to the North Dakota border (river km 18). The largest and most important of these spawning areas occurs just downstream from Intake diversion. The spawning population at this site in 1978 was estimated to be 991 walleye per kilometer. Favorable spawning flows at the Intake gravel bar were predicted to range between 6,000 to 11,000 cfs. Walleye chose to spawn over a pebble or cobble substrate, in water velocities of 43-96 cm/s, and a minimum depth of 30 cm. Few walleye spawning areas were found downstream

from Sidney (river km 56) because of reduced velocities and unsuitable substrate in this section of river. Water temperature during peak spawning was usually 12°C or greater.

After spawning the majority of walleye return downstream to Garrison Reservoir while most sauger remain near the mouth of the two tributaries or migrate upstream. Intake diversion (river km 114) does not appear to severely impede upstream movement of sauger while Forsyth diversion (river km 381) may hinder fish passage.

Sauger and walleye larvae hatch during the end of April or beginning of May when water levels are beginning to increase from mountain runoff. The distribution of larvae and young-of-year sauger indicate that virtually all sauger hatched in the Tongue and Powder rivers drift to downstream areas near the mouth of the Yellowstone River (distances up to 300 river km). No young of year walleye were collected in the Yellowstone River suggesting that virtually all walleye drift into Garrison Reservoir.

Sauger move upstream during the first year of life. By autumn a few young of year were captured as far upstream as Miles City (river km 298) and Forsyth (river km 381).

Estimates of the sauger population at Miles City during the fall of 1978, 1979, and 1980 were 248, 177, and 226 per kilometer, respectively. Low numbers in 1979 may have been the result of severe ice conditions during the previous winter.

INTRODUCTION

The Yellowstone River and two of it's major tributaries, the Tongue and Powder rivers, pass through lands undergoing or slated to undergo energy development. The purpose of this study was to gain a better understanding of the ecology of sauger and walleye in the lower Yellowstone River system in order to predict potential impacts from energy related development.

One of the major potential impacts of energy development is the removal of vast amounts of water for energy conversion facilities such as coal generation and gasification plants. The historic average annual discharge of the Yellowstone River near its mouth was 11 to 12 million acre-feet (MAF). Present use has reduced that to 8.8 MAF. With the number of requests for large volumes of Yellowstone River water drastically increasing, particularly from the industrial sector, the 1973 Montana Legislature established the Montana Water Use Act which recognized the value of fish and wildlife. This act allowed the Montana Department of Fish, Wildlife, and Parks (DFWP) to file for instream flows. On December 15, 1978, largely on the basis of research conducted by the DFWP and supported by numerous cooperators, the Board of Natural Resources granted an instream flow reservation of 5.5 million acre feet (MAF) for the Yellowstone River near its mouth (this includes an instream flow request by the Montana Board of Health) (Peterman 1979). Section 85-2-316 paragraph 7 of the Montana Use Ace stated:

> The board shall, periodically but at least once every 10 years, review existing reservations to ensure that the objectives of the reservation are being met. Where the objectives of the reservation are not being

met, the board may extend, revoke, or modify the reservation.

A major objective of this report is to provide information for this review process.

The two major species addressed in this report are sauger (Stizostedion canadense) and walleye (S. vitreum). This study builds upon ground work laid by Peterman and Haddix (1975), Haddix and Estes (1976) and Rehwinkel (1978). Much unpublished data from the Tongue and Powder rivers collected by Al Elser (Fisheries Manager, Montana Dept. Fish, Wildlife and Parks) was also incorporated into this report.

DESCRIPTION OF STUDY AREA

The Yellowstone River drainage contains approximately 182,336 km^2, 92,981 of which lie in Montana (Figure 1). It originates in the mountains of northwestern Wyoming and flows in a general northeasterly direction to its confluence with the Missouri River in North Dakota, 1,091 km downstream. Approximately 885 km of the Yellowstone River are in Montana. Average gradient is 2.44 m/km, 1.53 m/km, and 0.53 m/km for the upper, middle, and lower reaches, respectively (Peterman and Haddix 1975 and Haddix and Estes 1976). Mean annual discharge based on a minimum of 51 years of data was (107, 200, 329, and 372 m3/s (3,773, 7,043, 11,605, 13,149 cfs) at Livingston, Billings, Miles City, and Sidney, respectively (U.S. Geological Survey 1978). Turbidity is seasonally high in the lower river. Based on 14 samples taken by the U.S. Geological Survey from March through September 1975, turbidity averaged 83, 110, and

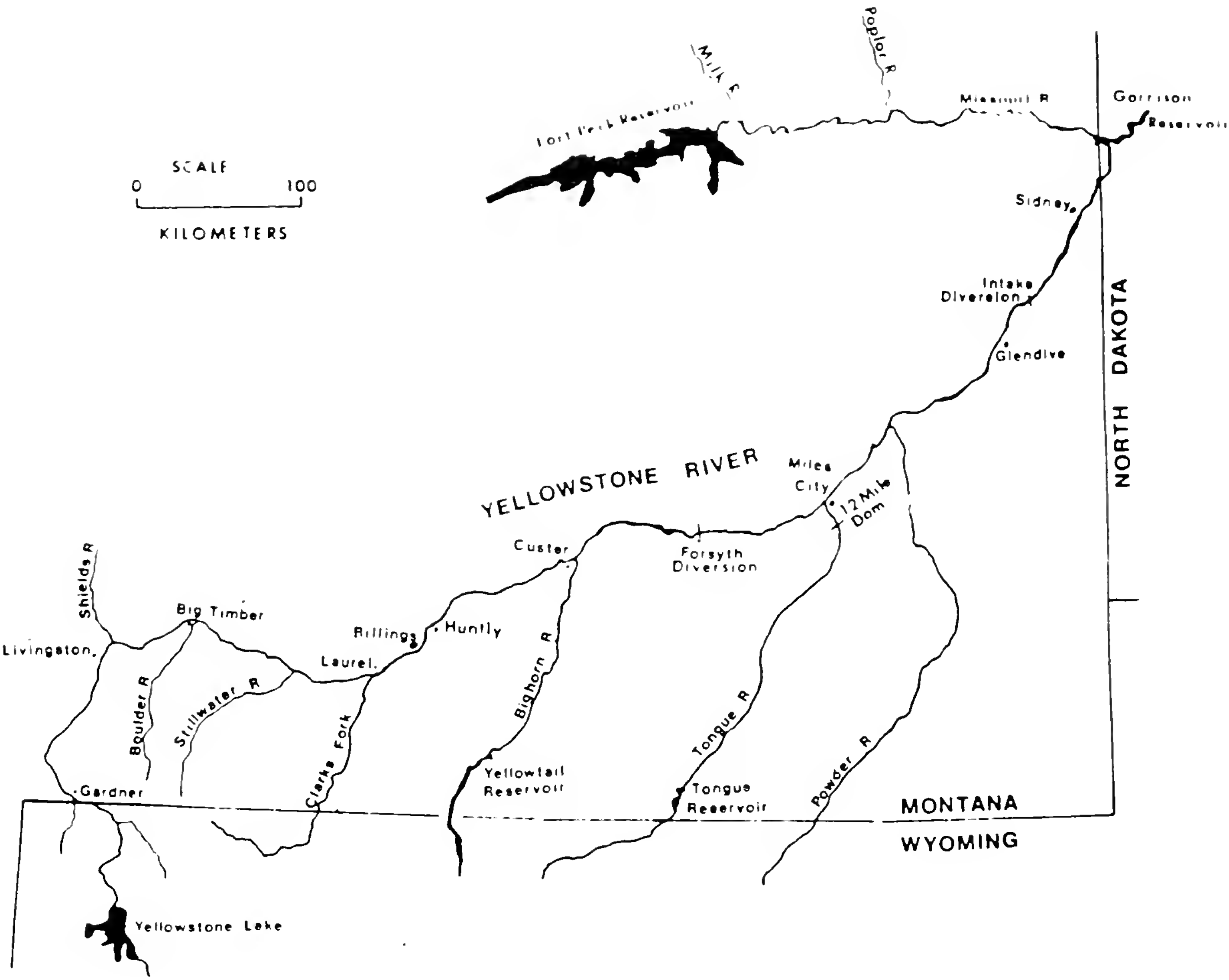

Figure 1. Map of the Yellowstone River drainage.

239 JTUs at Huntley, Miles City, and Sidney, respectively (U.S. Geological Survey 1975). Turbidity increases in the Yellowstone River downstream from the Powder River. Turbidity in the lower Powder River averaged 714 JTUs for 7 samples taken from March through September in 1975.

The Yellowstone River supports a trout fishery in the upper reach and a warmwater fishery in the lower reach. Diversity of species increases progressively downstream. Peterman and Haddix (1975) reported that eleven fish species (5 families) have been recorded in the upper Yellowstone River in Montana, 20 species (8 families) in the middle river, and 46 species (12 families) in the lower river. Two additional species were collected from the Yellowstone River in 1980; rainbow smelt (*Osmerus mordax*) and white bass (*Morone chrysops*) (Table 1.)

Newell (1976) determined that a rich aquatic invertebrate population is present in the Yellowstone River with both number of species and standing crop decreasing from the upper to the lower river. Mayflies (*Ephemeroptera*), caddisflies (*Trichoptera*), and true flies (*Diptera*) dominated the bottom fauna. The stonefly fauna (*Plecoptera*) was diverse but not abundant and decreased in number of species downstream.

The present study encompassed the lower half of the Yellowstone River from Huntley, Montana (river km 566) downstream to the North Dakota border (approximately river km 18) (Figure 1). Major tributaries along the lower river are the Big Horn River (river km 476), Tongue River (river km 298), and Powder River

Table 1. 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
Moxostomma macrolepidotus	Shorthead redhorse
Catostomus catostomus	Longnose sucker

Table 1 continued.

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 candense	Sauger
Stizostedion vitreum	Walleye
SCIAENIDAE (Drum family)	
Aplodinotus grunniens	Freshwater drum
COTTIDAE (Sculpin family)	
Cottus bairdi	Mottled sculpin
PERCICHTHYIDAE (Temperate bass family)	
Morona chrysops	White bass
OSMERIDAE (Smelt family)	
Osmerus mordax	Rainbow smelt

(river km 240). Several major diversions are present on the lower Yellowstone River. Forsyth (Cartersville or Rosebud) diversion, located at river km 382 and Intake diversion, located at river km 114 are two major diversion dams.

Forsyth diversion dam is a concrete structure extending 230m across the entire width of the Yellowstone River and diverts water for irrigation along the north side of the river. During intermediate to low flows the structure creates approximately a 0.5 to 1.0m vertical drop. During high spring flows and when ice jams form below the diversion the difference between water elevations immediately upstream and downstream from the diversion is less pronounced.

Intake diversion extends 219m across the main channel of the Yellowstone River and provides water for irrigation along the north side of the Yellowstone River. A side channel, which begins to flow at a total discharge of 23,000 cfs, bypasses Intake diversion to the south. The head and tail are approximately 3 km upstream and 3 km downstream from the diversion. The diversion is a wooden structure which has been covered by large boulders to raise the head. New boulders are placed on the diversion every few years to replace boulders which are pushed downstream by ice and high water. The diversion does not form a sharp vertical drop. The downstream drop is approximately 1.2 m in 30 m and is characterized by very turbulent water. The structure can divert a maximum of 33.0 m3/s (1,200 cfs).

Major habitat components of the lower Yellowstone River are main channel pools, runs and riffles, side channels or chutes, and backwaters. Pools are generally 1.5 m to 3.0 m deep, although some are at least 5.5 m deep during summer flows. Backwaters, an integral part of the river ecosystem, are much more common in island or braided sections of the Yellowstone River.

The lower Yellowstone River contains many islands and braided areas with the exception of the reaches from Miles City (river km 306) to Cedar Creek (river km 172) and Sidney (river km 40) to the mouth. The Miles City to Cedar Creek sections runs through several bedrock outcrops. Downstream from Sidney (river km 56), the Yellowstone widens and has a shifting sand and silt bottom.

Substrate in the main channel of the Yellowstone upstream from Sidney, Montana (river km 56) is dominated by clean, rounded cobble. Side channels are also dominated by a cobble or pebble substrate. When flows decline in late summer, many of the side channels become backwaters at which time large amounts of silt are deposited at the mouths of these channels.

The Yellowstone River is undammed. There are two periods of peak flows (Figure 2). The first and smaller peak occurs during mid March to early April and is a result of lowland or prairie runoff. This runoff period usually accompanies ice breakup. Because ice out begins in upstream areas, ice jams often form which can cause severe flooding. Ice out can be as much as 3 weeks

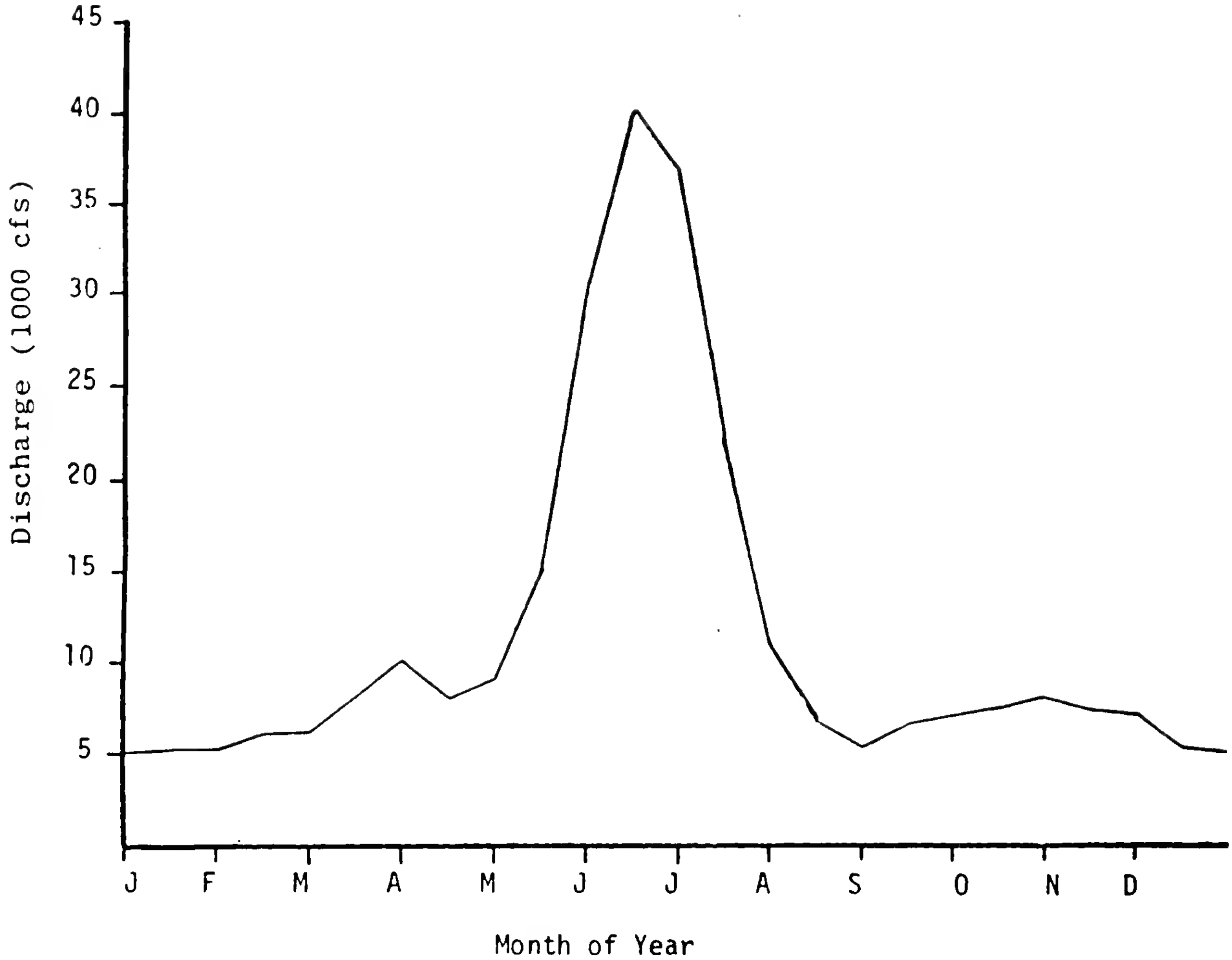

Figure 2. Median discharge of the Yellowstone River near Sidney, 1936-1974 (U.S. Geological Survey flow duration hydrograph).

earlier on the Yellowstone River than the Missouri River. Ice floods can alter channel banks and vegetation and can scour the river bed.

The second, much larger peak flow spans the period from early May until early August and is a result of mountain runoff (Figure 2). It is during this period that many side channels are filled when at other times of the year they may be dry or only backwaters. These high flows tend to scour the bottoms of side channels and remove sediments deposited during low water periods. High flow maintains the integrity of the river channel and islands (Peterman 1979 and Martin 1977). Large amounts of suspended sediments are carried by the Yellowstone during this time of year. Except for this mountain runoff period little stream bank vegetation contacts the water and very few macrophytes are found in the river.

Elser and McFarland (1977) and Rehwinkel (1978) found spawning migrations of Yellowstone River fish in the lower Tongue and Powder rivers. These two streams have similar flow patterns as the Yellowstone River. The Powder River has much greater concentrations of suspended sediment than both the Yellowstone and Tongue rivers. The greatest concentrations of suspended sediments occur in these two tributaries during periods of runoff or precipitation. Despite the turbid nature of these 2 rivers, the major substrate is fine pebbles often intermixed with fine coal. Flow in both streams is generally confined to a single channel. Because of low flows in late summer and early fall, there are few resident game species in the lower reaches of these two rivers. A concrete diversion dam, approximately 3 m high, spans the Tongue River 32 km upstream from its mouth. This diversion prevents all upstream fish movement.

METHODS

Walleye and sauger were sampled by electrofishing from a 5.2 m flat bottomed aluminum boat powered by a 85 hp motor (Graham et al 1979). The electrode array was set up for pulsed direct current as described by Novotony and Priegel (1974). The power source was a 220v, 3500w generator, with the output regulated by a variable voltage pulsating unit (Coeffelt VVP-10). Output current ranged from 10-15 amps at 100-200v. The pulse frequency was 80-100 pulses per second and the pulse width was 50-80 percent.

Total length of each fish was measured to the nearest mm and weight was determined to the nearest 10 g. Sex of mature fish was determined by the presence of sex products. For fish from which sex products could not be extracted, a distended abdomen and enlarged or inflamed genital area indicated a gravid female; whereas a flaccid abdomen and inflamed genital area indicated a spent female. All other fish were recorded as unknown sex. Fish were tagged with numbered floy anchor tags, inserted near the posterior base of the first dorsal fin.

To determine relative abundance and monitor fish movements, sampling stations were established in the Yellowstone River at: Forsyth, mouth of Tongue River, mouth of Powder River, and downstream from Intake diversion (Figure 3). The Forsyth section began immediately below an irrigation diversion and extended

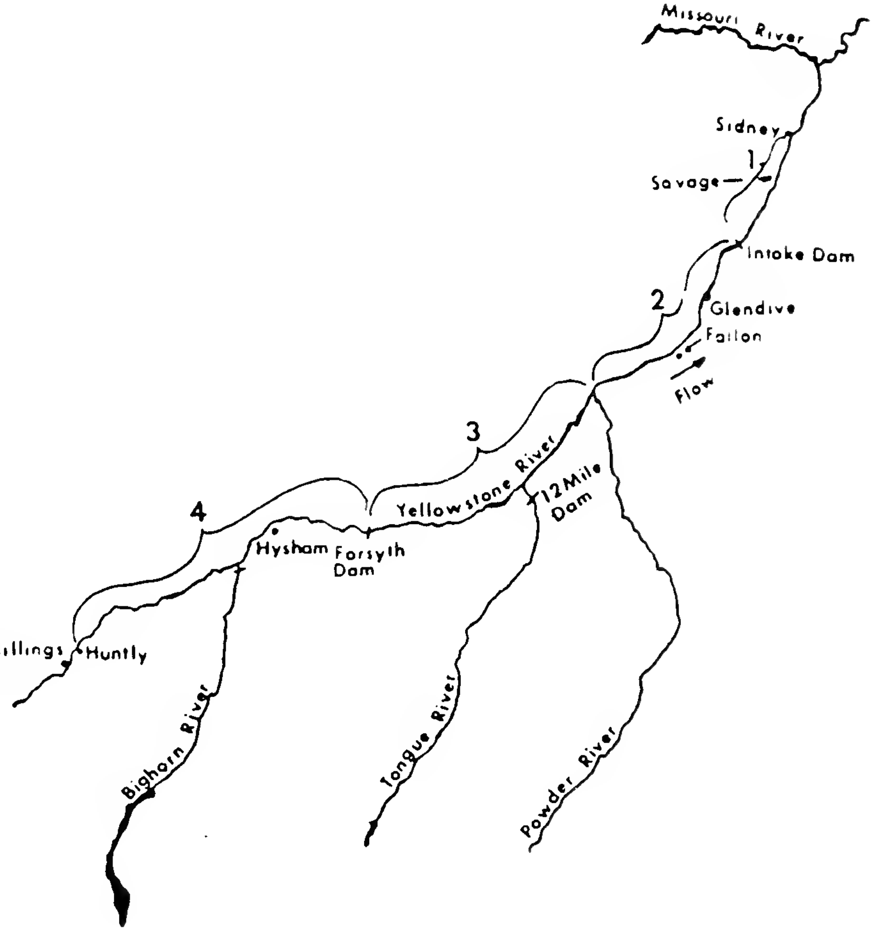

Figure 3. Map of the lower Yellowstone River showing the four study sections.

downstream 4.8 km. The section near the Tongue River began 3.2 km upstream from the mouth and extended 8 km downstream. Two sections near the Powder River included one which began at the mouth and extended 7.1 km upstream and another which began at the mouth and extended 2.4 km downstream. The Intake study area began at the irrigation diversion and extended 2.6 km downstream. Both sides of the river were sampled in all study sections except below the mouth of the Powder where only the south side was sampled (in turbid effluent from the Powder).

To locate mainstem spawning grounds at locations other than established sampling stations, two reaches of the Yellowstone River from Forsyth to the mouth of the Tongue River (84 river km) and from the mouth of the Tongue River to the North Dakota border (272 river km), were electrofished (Figure 3). The first was sampled during May 2-3, 1979 and the second from April 19-27, 1980. The entire length of these sections were sampled (one side) when large concentrations of gravid sauger were known to be present in the Tongue and Powder rivers.

To identify spawning areas for sauger in the Tongue River, the reach from Twelve Mile Dam to the mouth (32 river km) was electrofished during May 9-10, 1979 (Figure 3). Sampling occurred while large concentrations of sauger were present in the Tongue River.

Unpublished electrofishing data form the Tongue and Powder rivers has been summarized and included in this report. Data from the Powder River prior to 1979 was collected in a study by

Rehwinkel (1978) while Elser and McFarland (1977) collected information on the Tongue River prior to 1978. A large portion of the data on both tributaries since that time has been collected by Al Elser (Fisheries Manager, Montana Dept. of Fish, Wildlife and Parks). Sampling in the tributaries followed methods closely described above with the exceptions that electrofishing in the Powder River prior to 1979 was accomplished with a small boat and hand held electrode (Rehwinkel 1978). Electrofishing in the Tongue River prior to this date was accomplished with a 110 v boom shocker (Elser and McFarland 1977). Sampling thereafter in both tributaries was achieved with a 220 v boom shocker as described above. The sample site in the Powder extended from its mouth to 1.4 km upstream. Abundance of sauger was monitored in the lower 6 km of the Tongue River.

Suspected spawning sites were sampled for eggs with an egg net; 51 cm square, 12.7 cm deep, and angled at the base (Priegel 1969, Graham et al. 1979). Standard kick samples were taken using the following method: one person held the net on the bottom while another kicked and swept his feet along the bottom moving toward the net from a distance of approximately 4.6 m upstream. Maximum depths at which samples could be taken was 0.9-1.1 m depending on velocity. Velocity, depths, and substrate particle size was recorded at each sample site. To identify the eggs according to species, eggs were taken into the lab and diameters measured to the nearest 0.01 mm with a dissecting scope and micrometer. To verify egg diameters as reported in the literature eggs from several ripe walleye and sauger were also measured.

Four transects on the Yellowstone River downstream from Intake diversion were sampled for sauger and walleye eggs during 1977 (Graham et al. 1979) through 1979. Hydraulic parameters at this site for various flows were predicted with the aid of the water surface profile program (Graham et al. 1979).

Eggs and larvae were collected as they drifted downstream by suspending 0.5 m standard plankton nets just below the surface of the water. Mesh aperture of the nets was 760 microns. Nets were secured to bridges or fence posts driven into the substrate. Water velocity, measured at the mouth of the nets, and length of time sampled was recorded to determine volume of water sampled. Drift samples were collected at 7 locations: 1) the Yellowstone River 3.2 km upstream from the mouth of the Tongue River; 2) the Tongue River 0.8 km upstream from its confluence with the Yellowstone, 3) the Powder River 0.8 km upstream from its mouth, 4) the Yellowstone River 0.2 km upstream from Intake diversion dam, 5) Intake diversion canal approximately 0.2 km form its source, 6) the Yellowstone River 1.4 km downstream from Intake diversion, and 7) the Yellowstone River approximately 19 km upstream from its confluence with the Missouri. Descriptions by Nelson (1968b), Scott and Crossman (1973), and Hogue et al. (1976) were used to identify eggs and larvae of sauger and walleye.

To determine late summer-fall distribution and abundance of young-of-year through adult sauger and walleye, 15 stations were electrofished during this time period from Huntley (river km 566) to Sidney (river km 56) (Figure 3). The stations were: 1) downstream from Huntley irrigation diversion, 2) near the mouth of the Bighorn River 3) the Bighorn River from a diversion dam to the mouth, 4) near Hysham downstream from an irrigation diversion, 5) upstream from Forsyth diversion, 6) downstream from Forsyth diversion, 7) near Hathaway, 8) near the mouth of the Tongue River, 9) 21 km downstream from the Tongue River, 10) near the mouth of the Powder River, 11) near Fallon, 12) near Hoyt (river km 192), 13) near Glendive, 14) downstream from Intake diversion, 15) near Savage, and 16) near Sidney. Each of these stations were approximately 8 km in length (except the Bighorn River station which was 4.8 km) and both sides were sampled. Catch rates were expressed as the number of fish captured per river kilometer (both sides) sampled. These stations were lumped into 4 river sections Figure 3) and data computed accordingly.

Movement of fish was determined by recapturing tagged fish with electrofishing gear or receiving voluntary returns from fishermen. Tag return analysis by season and location was aided with a computer program (Graham et al. 1980). A difference of at least 8 km between the release and recapture location of the fish was necessary before it was considered movement. Recaptures caught at the same location during the same season of the same year were not included in movement analysis.

Population and standing crop estimates were obtained for the spawning walleye population downstream from Intake diversion, 1978 and for the Yellowstone River sauger population at Miles City, late summer-autumn, 1978-1980. Fish were captured with electrofishing gear and a multiple census technique was employed using the Schumacher-Eschmeyer estimate (Ricker 1975). Population statistics were computed with the aid of a computer program (Penkal 1981). Fish were aged by reading scales which were collected from an area below the first dorsal fin and above the lateral line. Cellulose acetate impressions of all scales were examined at 66 x magnification.

Daily flow records and water temperatures were obtained from U.S. Geological survey Water Resource Data. Constant recording thermographs were installed at various locations where the Geological Survey did not have temperature recording stations.

RESULTS AND DISCUSSION

Life History and Population Statistics of Sauger

Chronology and Abundance During Spring

Ripe male sauger were present in the lower Tongue and Powder rivers during the last week of March through the first week of May

(Figures 4 and 5). Female sauger were also present in these two tributaries as early as late March but were not collected in a ripe or spent condition until mid April to mid May depending on the year.

It appeared that large numbers of male sauger moved into the Powder River earlier than in the Tongue River. Maximum peaks occurred 23 days earlier in the Powder than Tongue River during 1978 and 1977 and 14 days earlier in 1976 (Figures 4 and 5). The Powder was not sampled during the early period in 1980. Female numbers appeared to peak slightly earlier in the Powder than Tongue River (8 days in 1980 and 4 days in 1978) or simultaneously as in 1977 and 1976.

Of the over 3,000 sauger captured in the lower Tongue and Powder rivers during March-May, 1976-1980, over 90 percent were sexually mature. Males comprised 84 and 79 percent of the sample in the two rivers, respectively (Table 2).

When numbers of mature sauger peaked in the Tongue and Powder rivers, numbers were at low levels or sharply declining in the Yellowstone River near the mouth of these tributaries (Figures 4, 5, 6, 7, and 8). Mature sauger were not abundant at other locations in the mainstem of the Yellowstone River (except occasionally downstream from Intake diversion) at a time when sauger were concentrated in the Tongue and Powder rivers (Figures 9 and 10).

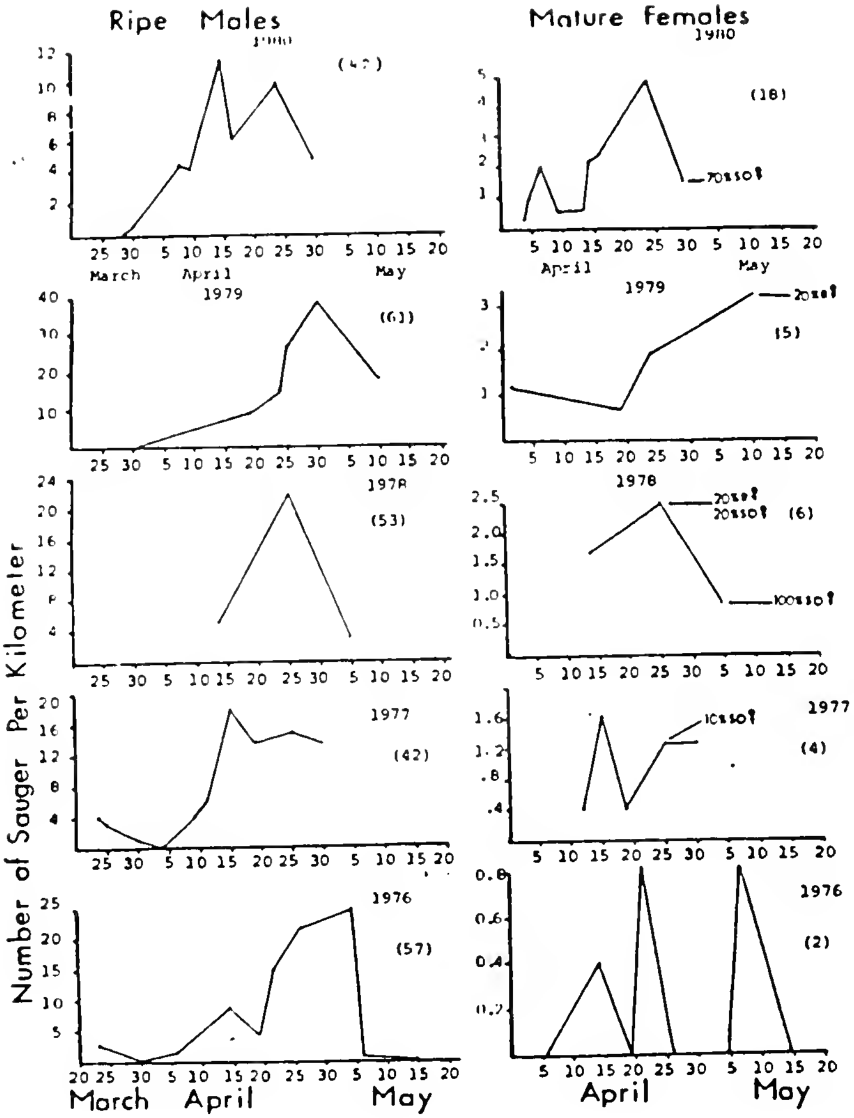

Figure 4. Number of ripe male and mature female sauger captured per kilometer while electrofishing the lower Tongue River, 1976-1980. Maximum one day sample size is in parentheses.

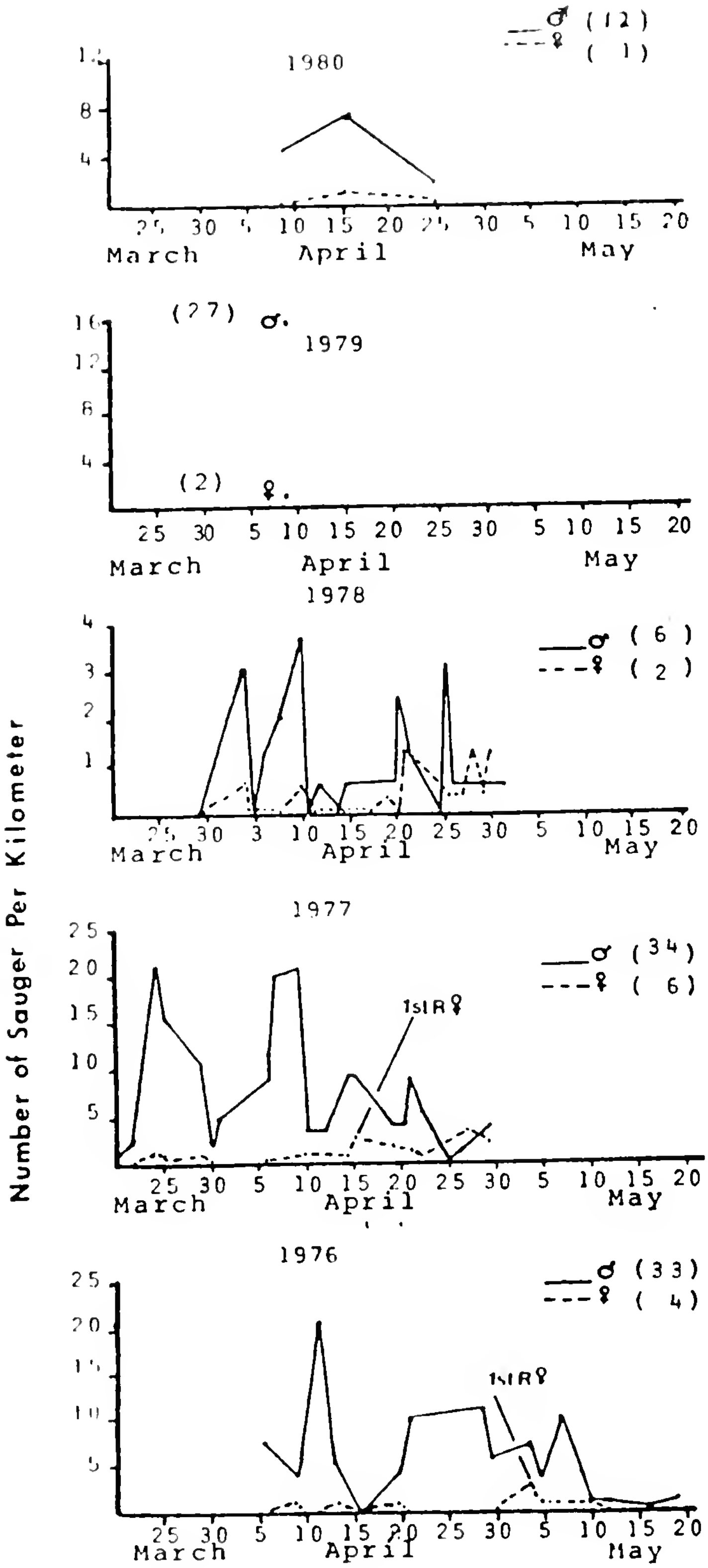

Figure 5. Number of sauger captured per kilometer while electrofishing the Powder River near its mouth, 1976-1980. The maximum number of fish sampled on one day is in parentheses.

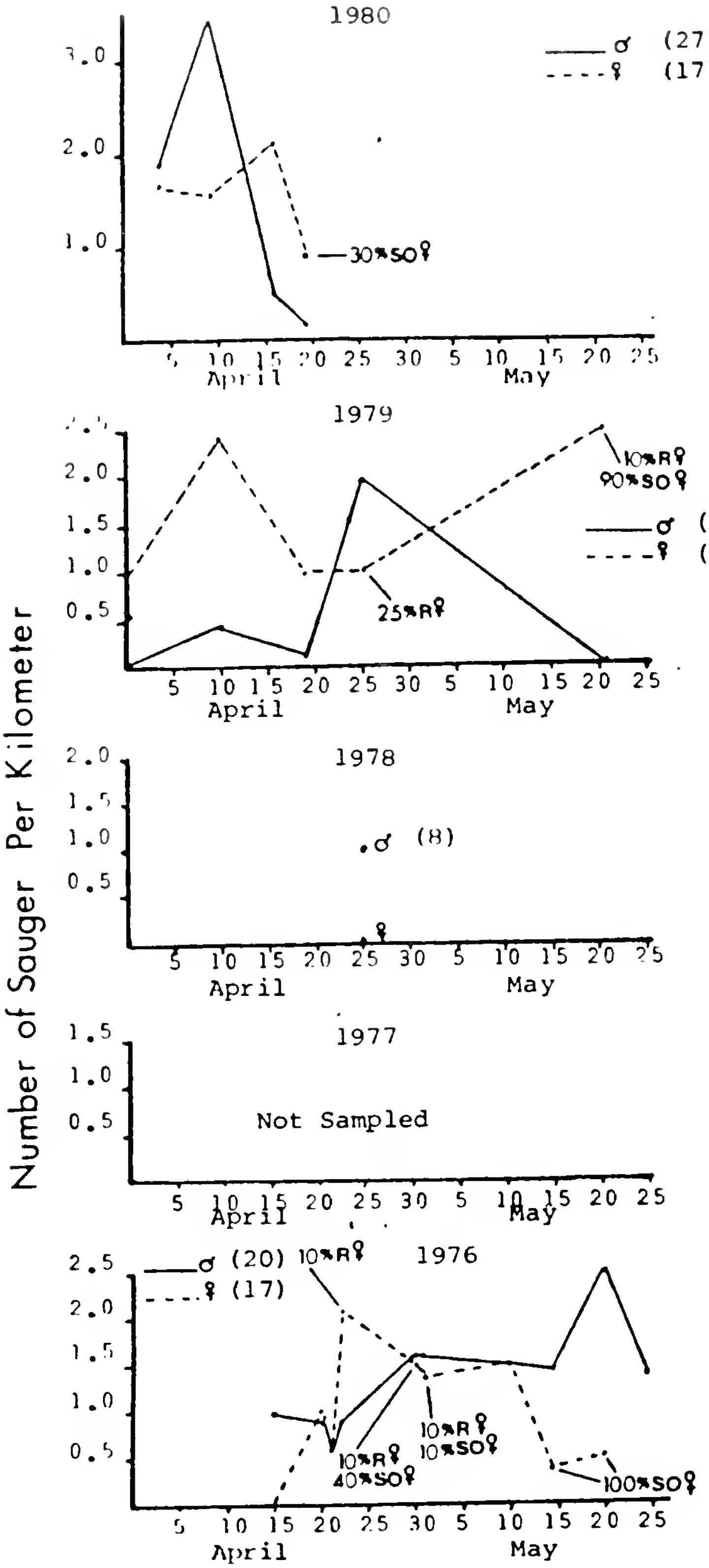

Figure 6. Number of sauger captured per kilometer while electrofishing the Yellowstone River near Miles City, 1976-1981. The maximum number of fish sampled in one day is in parentheses.

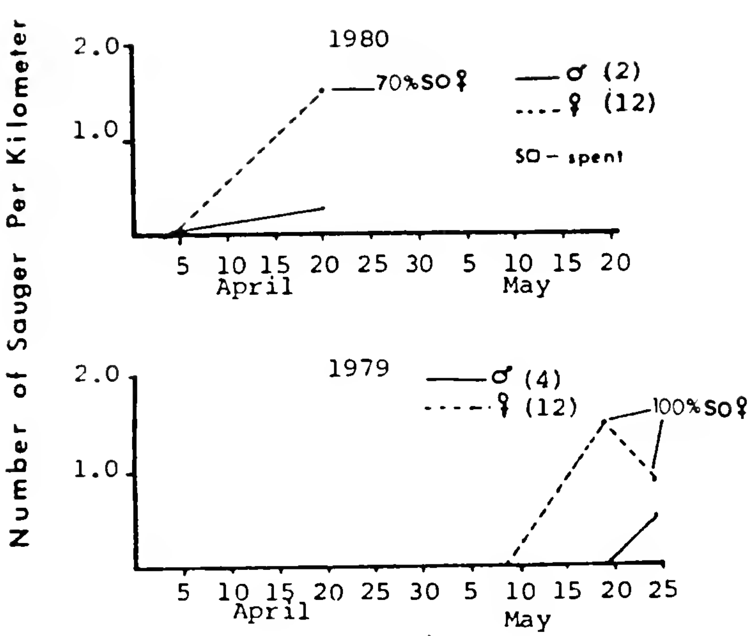

Figure 7. Number of sauger captured per kilometer while electrofishing the Yellowstone River upstream from the mouth of the Powder River, spring 1979 and 1980. The maximum number of fish sampled in one day is in parentheses.

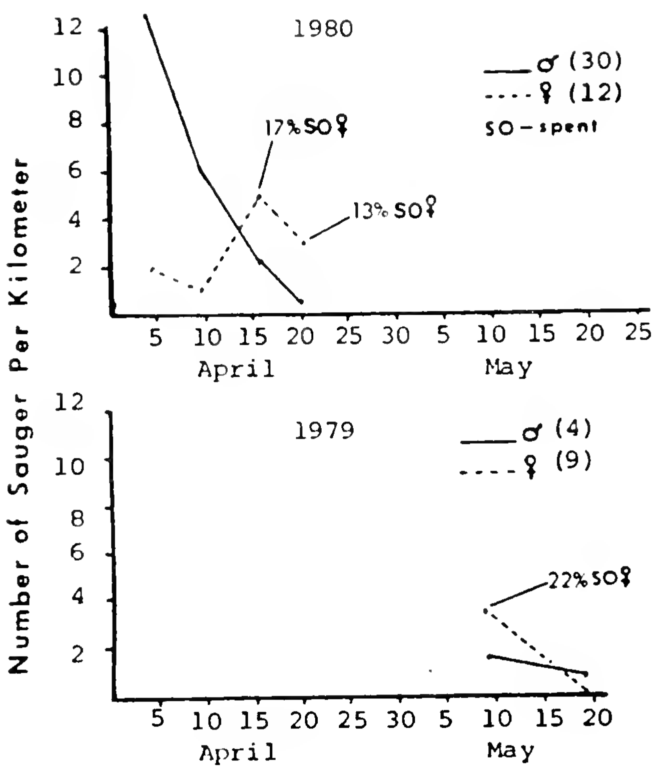

Figure 8. Number of sauger captured per kilometer while electrofishing the Yellowstone River downstream from the mouth of the Powder River, spring 1979 and 1980. The maximum number of fish sampled in one day is in parentheses.

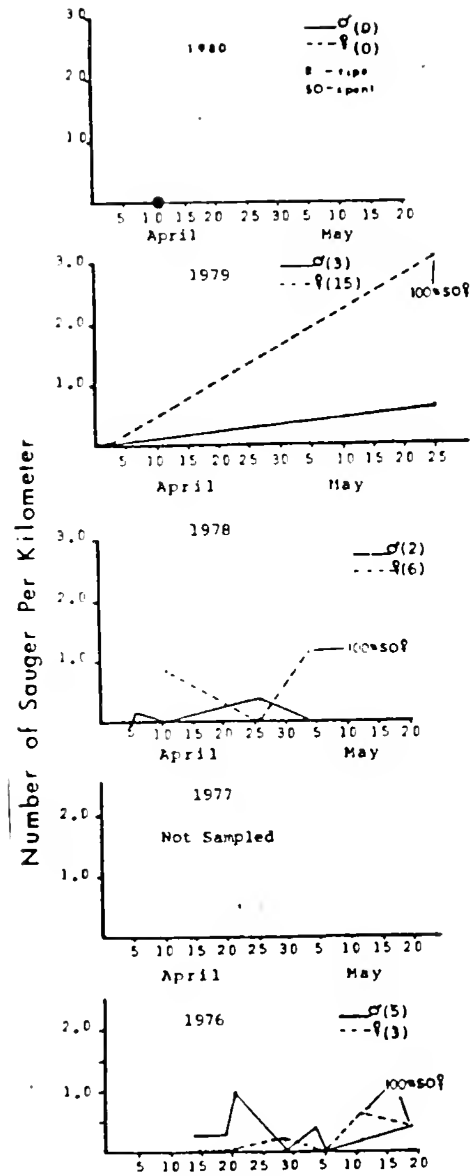

Figure 9. Number of sauger captured per kilometer while electrofishing the Yellowstone River downstream from Forsyth diversion, spring 1976 -1980. The maximum number of fish sampled in one day is in parentheses.

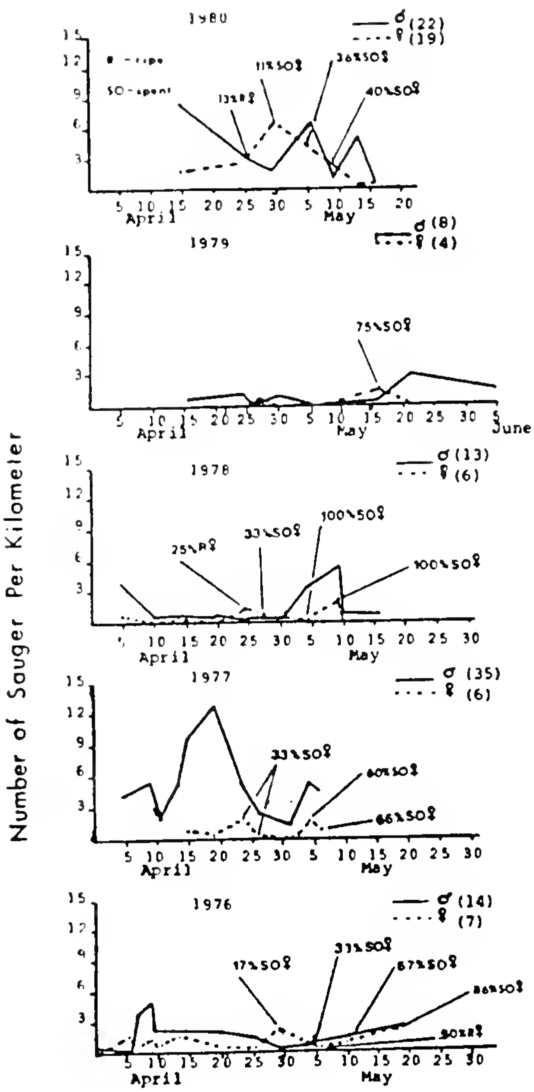

Figure 10. Number of sauger captured per kilometer while electrofishing the Yellowstone River downstream from Intake diversion, spring 1976 - 1980. The maximum number of fish collected in one day is in parentheses.

Table 2. Number and (percent), by sex of sauger captured in the Yellowstone drainage during the sauger spawning period, March-May, 1976-1980.

Location	Number Captured	Sex (Percent) Males	Females	Immature or Undetermined
Tongue River	2546	2139(84)	229(9)	178(7)
Powder River	620	489(79)	50(8)	81(13)
Yellowstone River at:				
Forsyth	306	18(6)	31(10)	257(84)
Miles City	853	188(22)	187(22)	478(56)
Mouth of Powder River	116	44(38)	22(19)	50(43)
Intake	1933	444(23)	155(8)	1334(69)

The sauger population in the Yellowstone River, during the period that numbers of mature sauger peaked in the tributaries, was dominated by immature fish. Immature sauger comprised 43 to 84 percent of the sample at Forsyth, Miles City, mouth of Powder River and Intake (Table 2). Fifty-six percent of the 256 sauger captured, while electrofishing the Yellowstone River from Miles City to North Dakota during the spring of 1980, were immature.

One side of the Yellowstone River from Forsyth diversion (river km 381) to Miles City (river km 294) was electrofished on May 2-3, 1979. During this time large numbers of sauger were in the Tongue and probably Powder rivers (Figures 4 and 5). Only one sexually mature sauger, a hard female, was collected in the Yellowstone. The only other mature sauger, a ripe male, was collected in Rosebud Creek (river km 362).

One side of the Yellowstone River from Miles City to the North Dakota border was electrofished from April 19 to 27, 1980. During this time large numbers of ripe sauger were present in the Tongue and Powder rivers (Figures 4 and 5). Only 116 mature sauger were collected in this 272 km section of the Yellowstone River (Figure 11). The catch rate for all mature sauger was only 0.4 fish/km. The greatest concentrations of fish were near the mouth of the Tongue and Powder rivers.

The small number of mature sauger (particularly males) found throughout the Yellowstone River during the spawning period suggests that sauger spawning was less concentrated in the mainstem than in the lower Tongue and Powder rivers.

Sex ratios (male:female) of mature sauger collected in the Tongue River were always weighed towards males, ranging from 2:1 to 89:1. Sex ratios in the Powder River were, except on two instances, weighted towards males. The sex ratios for all mature fish collected from the Powder (n=573) and Tongue (n=2637) rivers during 1976 through 1980 were 9:1 for both tributaries. Sex ratios in the Yellowstone River at the onset of spawning (the day the first ripe or spent female was collected) with few exceptions were weighted towards females, usually 1:2 or less.

The preponderance of males in the Tongue and Powder rivers during the spawning period suggest these two tributaries are important spawning areas for this species. Preigel (1970) found males comprised 70 to 90 percent of mature walleye captured on tributary spawning grounds to Lake Winnebago, Wisconsin. In contrast, the general paucity of male sauger in the Yellowstone River suggests that spawning is more dispersed in the mainstem.

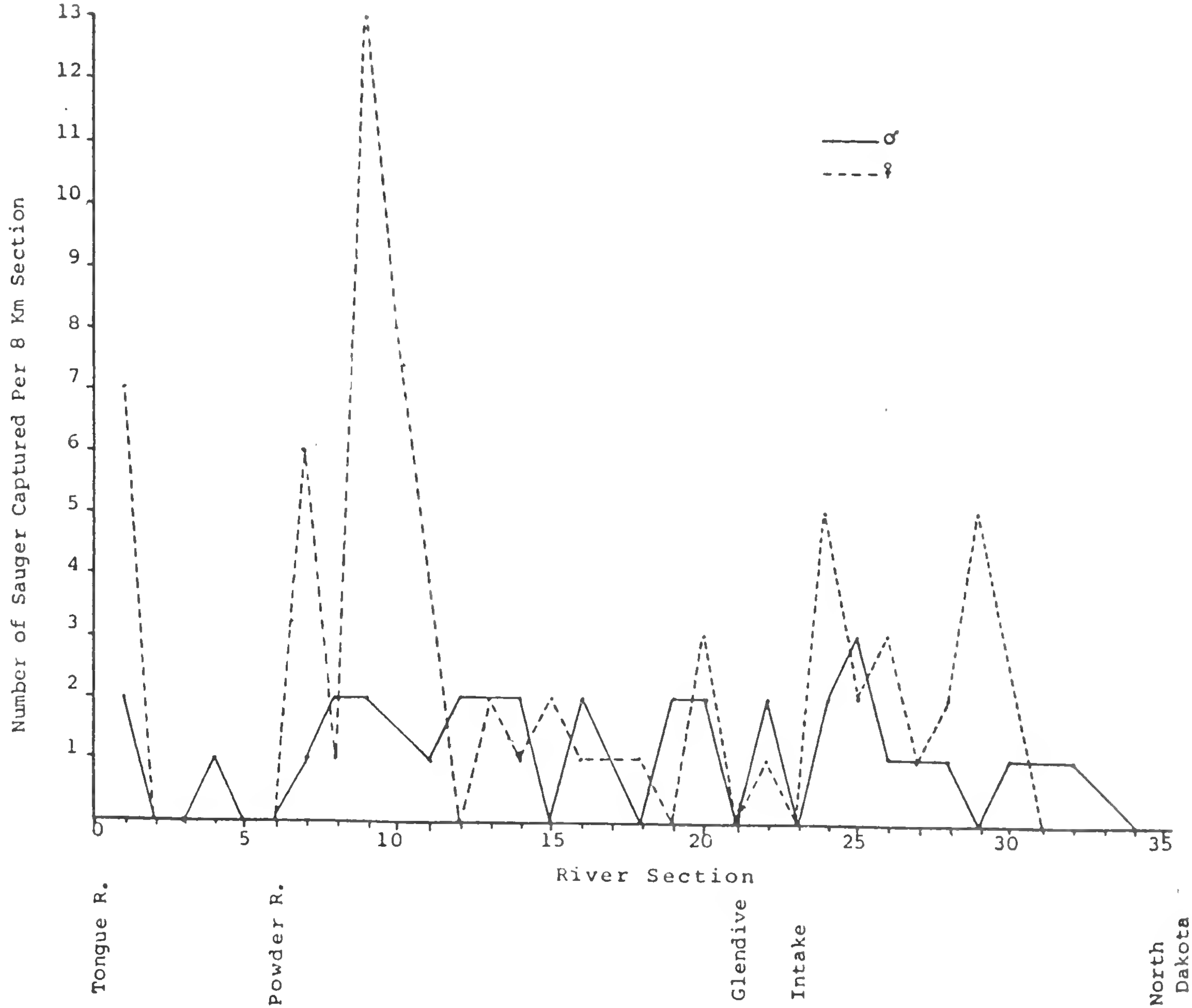

Figure 11. Electrofishing catch rates for mature sauger captured in 8 km sections of the Yellowstone River from Miles City to North Dakota, April 19-27, 1980.

The preponderance of male sauger in tributary spawning streams is probably related to the fact that most males in the Yellowstone River mature at age 3 while most females are not mature until age 5. Also, males tend to enter the spawning areas earlier than females and remain throughout the spawning period while females are usually present only for the short time necessary to complete spawning activities.

Recapture Rate During Spring

Sauger were readily recaptured in the Tongue and Powder rivers, the same spring they were tagged in these tributaries. Depending on the year as many as 118 and as few as 8 sauger were recaptured in the Tongue River during the same year, 12 and 2 percent of the total number of sauger captured, respectively. For all years combined, 8 percent of the sauger captured were recaptured in the Tongue River the same year they were tagged.

The number of sauger recaptured within the Powder River during the same spring they were tagged in this tributary ranged from 1 to 18, 1 and 6 percent of the total sample, respectively. Priegel (1970) observed that male walleye arrived early on spawning grounds and remained throughout the spawning period. Over 90 percent of the sauger captured in the Tongue and Powder rivers were males, and the incidence of recaptures suggests that: 1) sauger, particularly males, remained in the Tongue and Powder rivers throughout the spawning period, and 2) the Tongue and Powder rivers are important spawning streams.

Sauger demonstrated a very high return rate to the Tongue River in subsequent springs (Table 3). Sauger tagged in the Tongue River during the spring of 1976-1979 represented 14 percent of the total number of fish captured once in the Tongue River during the spring of 1980.

Fifty-one sauger were captured in 1977 that were tagged the previous spring, representing 10 percent of the sample. Elser and McFarland (1977) estimated the number of sauger entering the Tongue River during 1976 to be approximately 4,000. If this number is accurate then 22 percent of the population was tagged in 1976. This suggests that 50 percent of the fish tagged in 1976 returned to the Tongue River in 1977. If the computations were adjusted for recruitment into the spawning population during 1977 or for mortality, the return rate would be much greater than 50 percent. The high return rate in subsequent years also suggests a high survival rate of sauger that move into the Tongue River during spring.

Individual sauger demonstrated a high return rate to the Tongue River in subsequent springs. Six sauger (all males) were tagged in 1976 and recaptured in two subsequent years during spring in the Tongue River. One sauger was tagged in 1975 and recaptured in the Tongue River in 1976 1977, and 1979.

Too few sauger were tagged in the Powder River to determine the return rate in subsequent years; only one fish was recaptured each year during 1977 through 1979.

Table 3. Number and (percent) of sauger recaptured in the Tongue River that were tagged in the Tongue River in previous years.

Year	New fish in Tongue River	Fish recaptured in Tongue River that were tagged at other locations	Number of recaptures from fish tagged in previous years in Tongue River	Total	Number of sauger caught which were tagged in the Tongue River during: 1979	1978	1977	1976
1980	186	5	32	223	20(9)	9(4)	1(0)	2(1)
1979	503	9	61	573	-	30(5)	16(3)	15(3)
1978	342	7	27	376	-	-	12(3)	15(4)
1977	444	12	51	507	-	-	-	51(10)
1976	878	6	-	884	-	-	-	-
Total	2353			2563	Summation = 171 (6.7)			

Several studies have shown a homing pattern by walleye to spawning areas (Forney 1963, Crowe 1962, Olsen and Scidmore 1962). Mature sauger in the Yellowstone River system tend to "home" to the Tongue and, probably, Powder rivers during the spawning period indicating these are important spawning areas.

Tag returns show that sauger migrated from all areas of the lower Yellowstone to enter the Tongue and Powder rivers during late March through early May (Figures 12 and 13). Tag returns from 64 sauger captured one or more years previous indicate that most (80%) of the sauger entering the Tongue River during spring migrated from areas in the Yellowstone near or upstream from the mouth of Tongue River. This was also true for the Powder River where 75 and 25 percent of the 20 recaptured sauger were tagged upstream and downstream from the Powder River, respectively. Sauger that migrated to these two tributaries from upstream areas were almost always sexually mature (over 90 percent), however, 40 and 60 percent of the sauger from downstream areas were immature in the Tongue and Powder rivers, respectively. This suggests that younger, immature sauger were entering the spawning population from rearing areas downstream while older, mature sauger were entering the spawning run from rearing areas near or upstream from the tributaries.

The major portion of the sauger, 68 and 65 percent, recaptured in the Tongue and Powder rivers, respectively, were caught during March through April which usually encompassed the height of the spawning run. The remainder were recaptured during May.

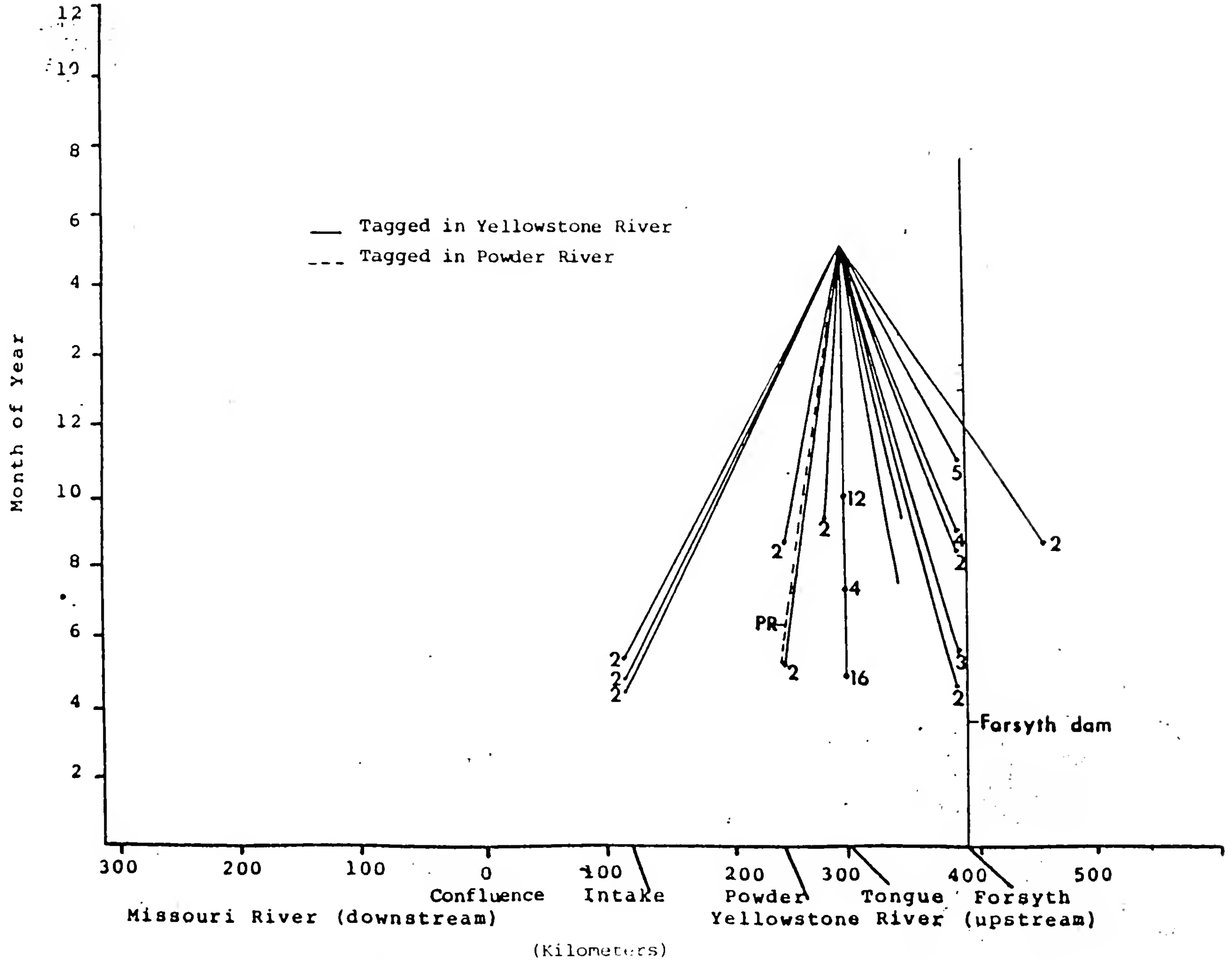

Figure 12. Sauger tagged in the Yellowstone and Powder rivers, 1974 - 1979 and recaptured in the Tongue River during the spring of a subsequent year.

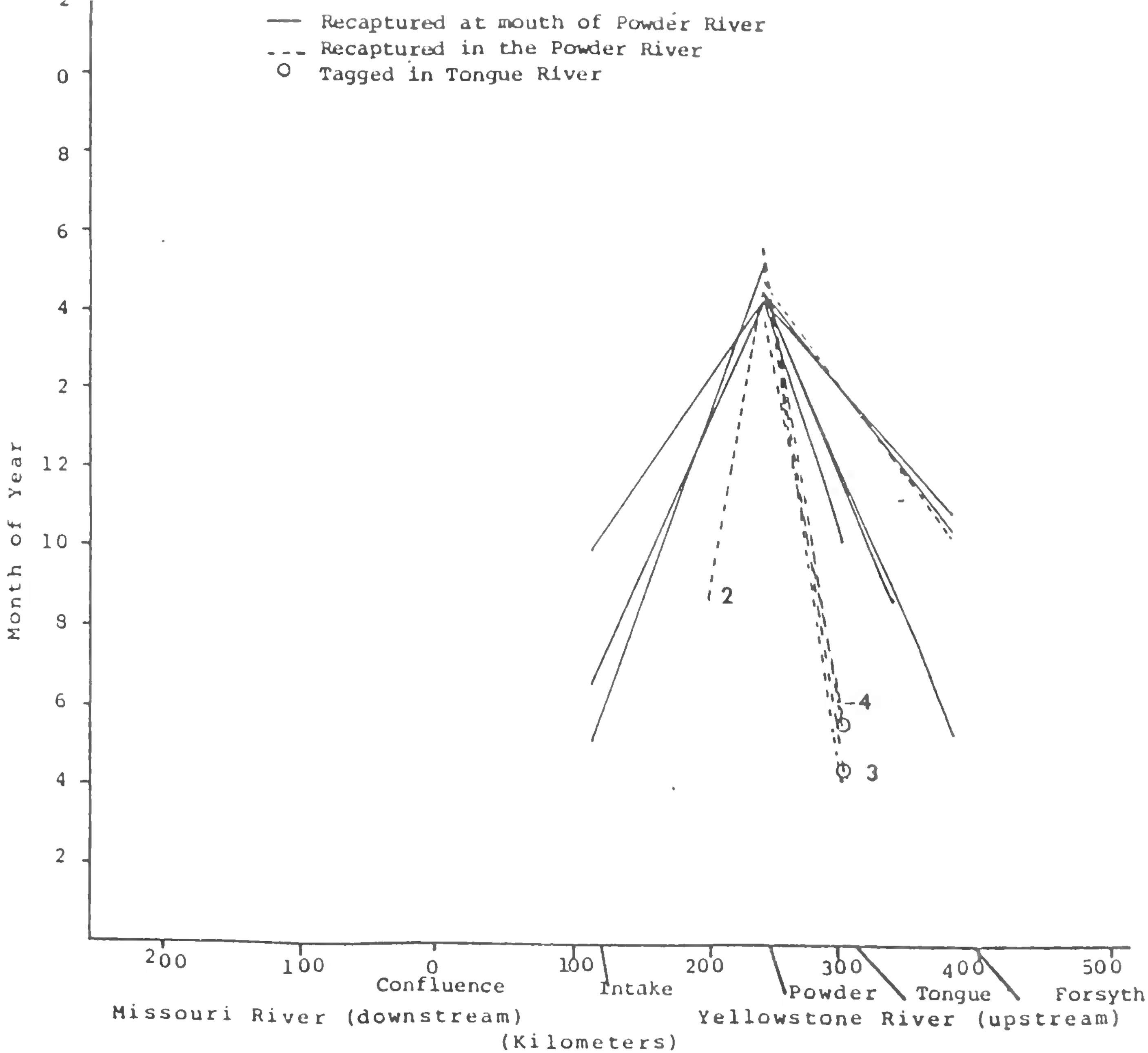

Figure 13. Sauger tagged in the Yellowstone and Tongue rivers, 1974 - 1979 and recaptured in a subsequent year in the Powder River or in the Yellowstone River near the mouth of the Powder River.

Eight sauger were recaptured in the Tongue River that were tagged at other locations during spring of the same year. Seven were tagged near the mouth of the Tongue in the Yellowstone River and one was tagged in the Powder River. Four sauger, all males, were captured in the Powder or near its mouth during spring that were tagged at other locations during spring of the same year. Two were tagged in the Tongue River and two in the Yellowstone near the mouth of Tongue River demonstrating some degree of interchange between these two tributary spawning streams.

Twenty-seven sauger were recaptured in the Yellowstone River near Forsyth during spring after being tagged a previous year at another location (Figure 14).

A total of 56 sauger were recaptured in the Yellowstone near Miles City during spring after being tagged a previous year at another location (Figure 15). Most (82%) were recaptured during the peak spawning period, March through April, and the majority (70%) were mature fish. Sixteen sauger that were tagged in the Tongue River during April were recaptured during May of the same year in the Yellowstone near the mouth of the Tongue River.

Other Sauger Movements

A total of 540 tagged sauger were recaptured in the Yellowstone River system during 1976 through 1980 (Table 4). Over twice as many were recaptured upstream after tagging (39%) than downstream (17%). Of the fish initially tagged in the Yellowstone River from the mouth of the Yellowstone River to the Tongue River, the majority of those recaptured at a location other than the site

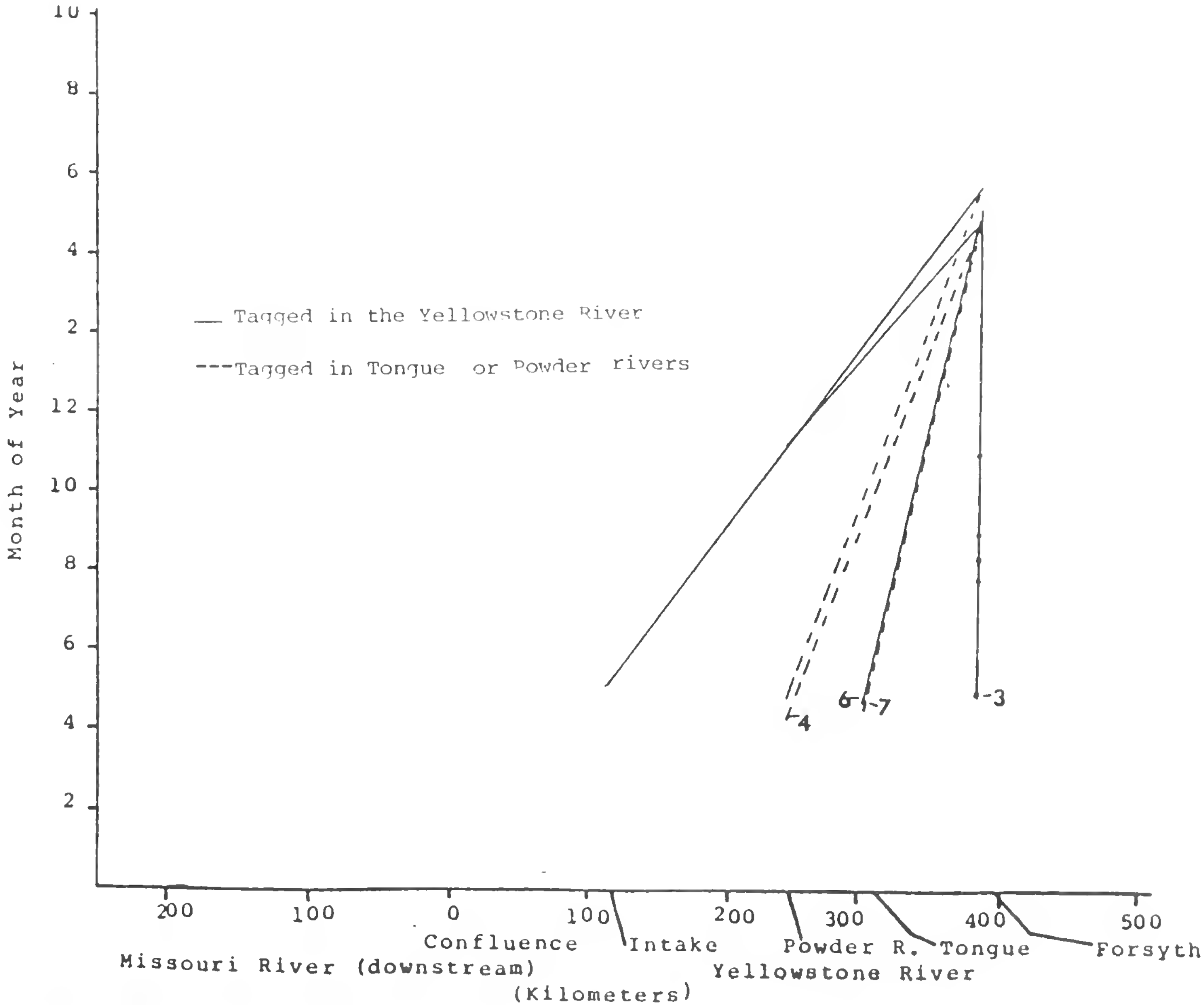

Figure 14. Movement of sauger tagged in the Yellowstone River or Tongue and Powder rivers and recaptured in the Yellowstone River downstream from Forsyth diversion during Spring, 1976-1980.

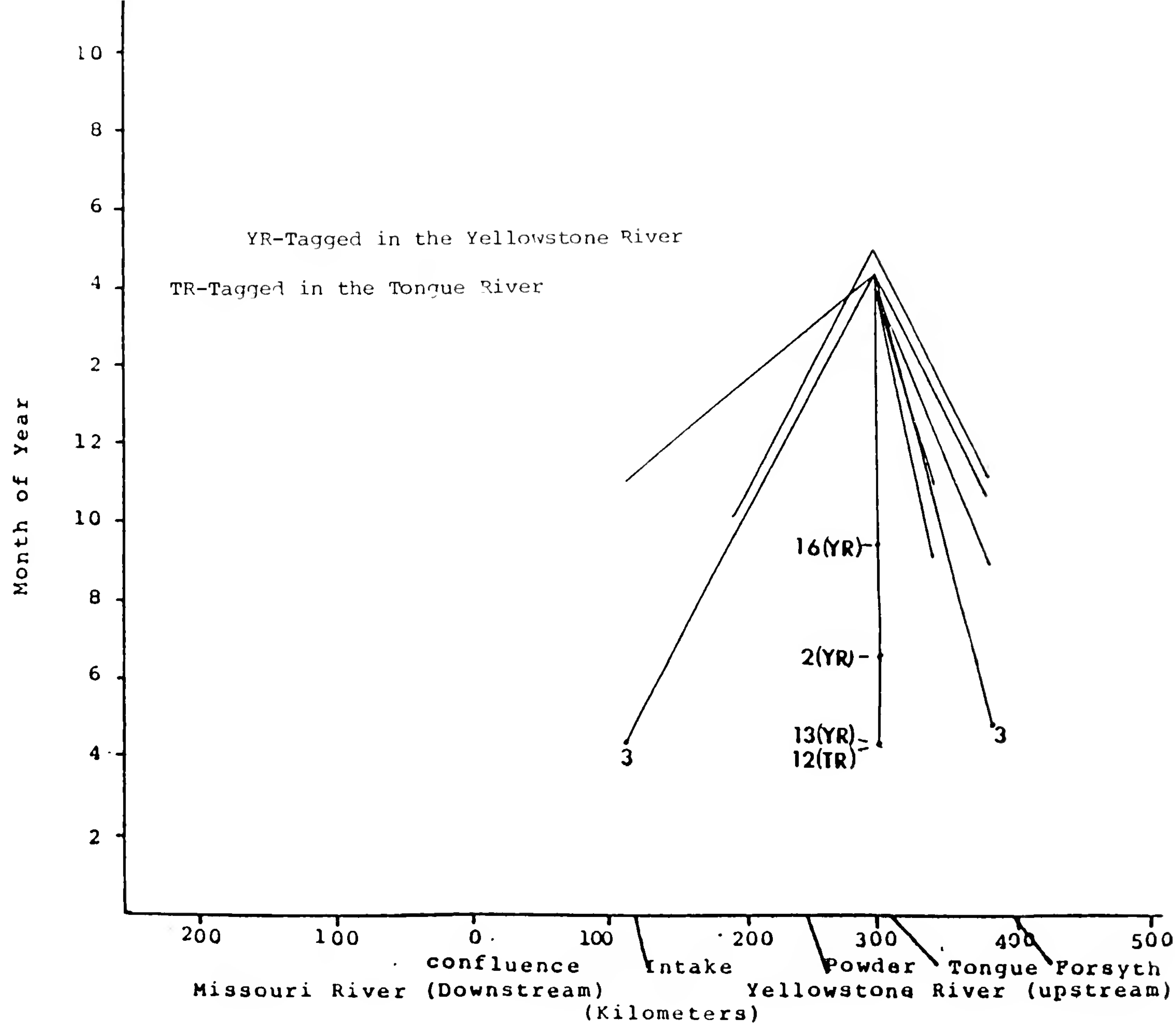

Figure 15. Movement of sauger tagged, 1974 - 1979 in the Yellowstone and Tongue rivers and recaptured in the Yellowstone River near Miles City during spring of a subsequent year.

Table 4. Summary of sauger tag returns and mean distance moved (d) in the lower Yellowstone River System.

Location of recapture	Total No. recaptured	Downstream		Upstream		Same Location
		%	d	%	d	%
Mouth Yellowstone R. to 8 km downstream Intake Dam	8	50	90	50	107	0
Eight km downstream Intake Dam to Intake Dam	76	20	182	61	188	18
Intake Dam to 8 km downstream Powder River	27	19	129	44	93	37
Yellowstone R. near mouth Powder River	22	41	161	41	80	18
Powder River	32	3	95	84	104	13
Yellowstone River near mouth Tongue River	164	9	99	42	19	49
Tongue River	105	8	70	31	88	61
Yellowstone River - Forsyth Dam to 8 km downstream	100	33	108	6	84	61
Yellowstone River - Forsyth Dam Upstream	6	67	176	17	100	17
Total	540	17	123	39	90	44

of tagging moved upstream. The majority of those captured upstream from the Tongue River moved downstream (Table 4). Mature fish remained near the mouth of tributaries or migrated upstream in the Yellowstone after spawning in the Tongue and Powder rivers. Sauger which reared upstream from these two tributaries migrated back downstream to enter the Tongue and Powder rivers during the spawning run. The movements of individual fish tagged in the lower Yellowstone River system are recorded on Figures A-1 through A-17.

A total of 120 sauger were recaptured downstream from Forsyth diversion (Figure 16). Forty-five (38%) were tagged in the Yellowstone River downstream to Intake; 45 (38%) in or near the Tongue River, 13 (11%) in or near the Powder River, and 13 (11%) downstream from Intake diversion. Almost all (97%) sauger were recaptured after the first of May demonstrating movement to this location after spawning occurred.

Fourteen sauger, tagged in the Yellowstone River from Forsyth diversion to the mouth of the Yellowstone or tagged in the Tongue and Powder rivers, were recaptured in the Yellowstone River upstream from Forsyth diversion (Figure 17). This represents 12% of the total number of sauger which were recaptured in the vicinity downstream (within 8 km) from the dam (Figure 16). Once the diversion is negotiated sauger will travel great distances upstream; one was captured 193 km upstream from Forsyth (river km 575).

Sauger ceased movement and became sedentary in late summer and fall. Also, fall tagged sauger appeared to return to the same

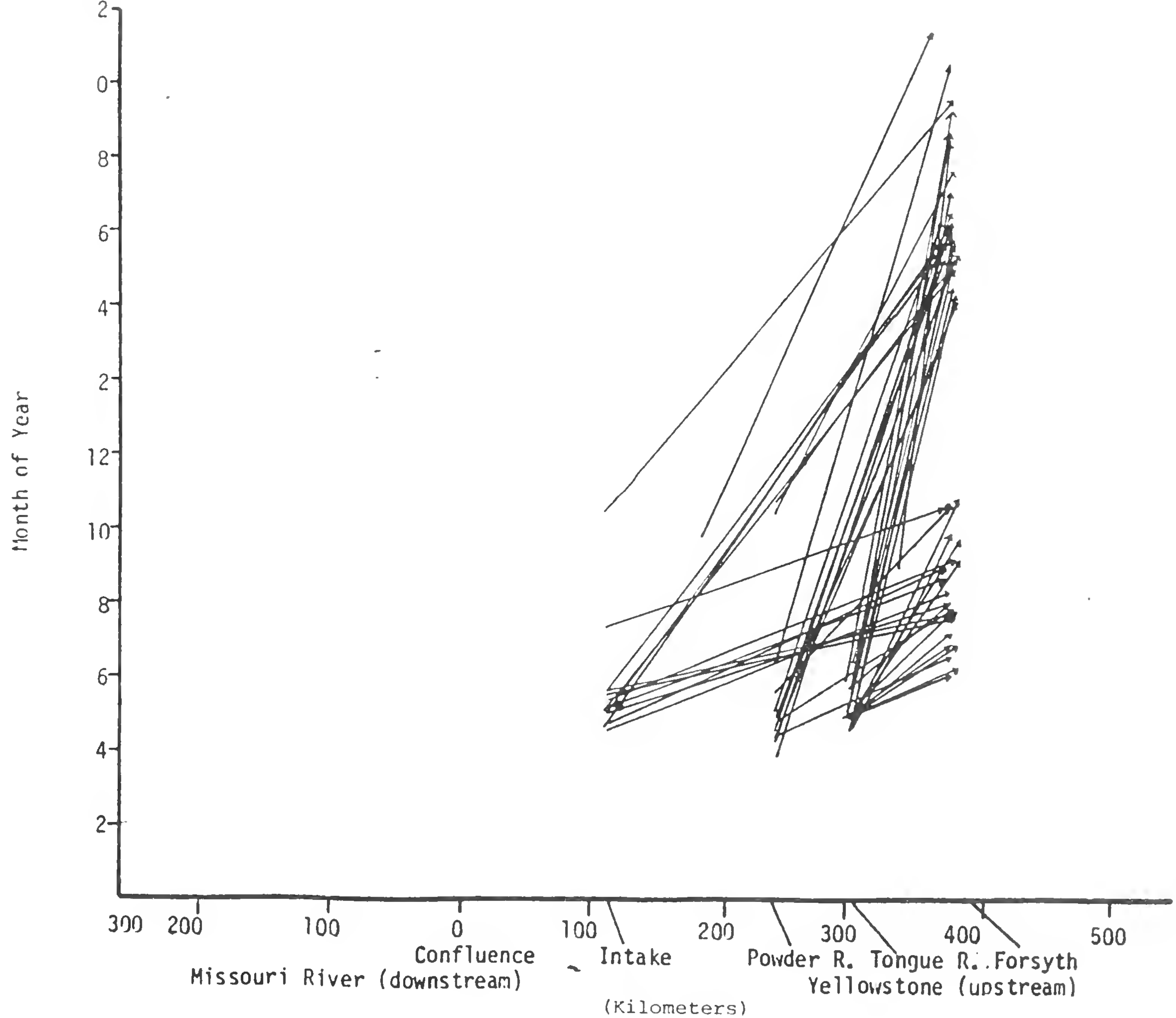

Figure 16. Movement of sauger recaptured below Forsyth diversion which were tagged at other locations.

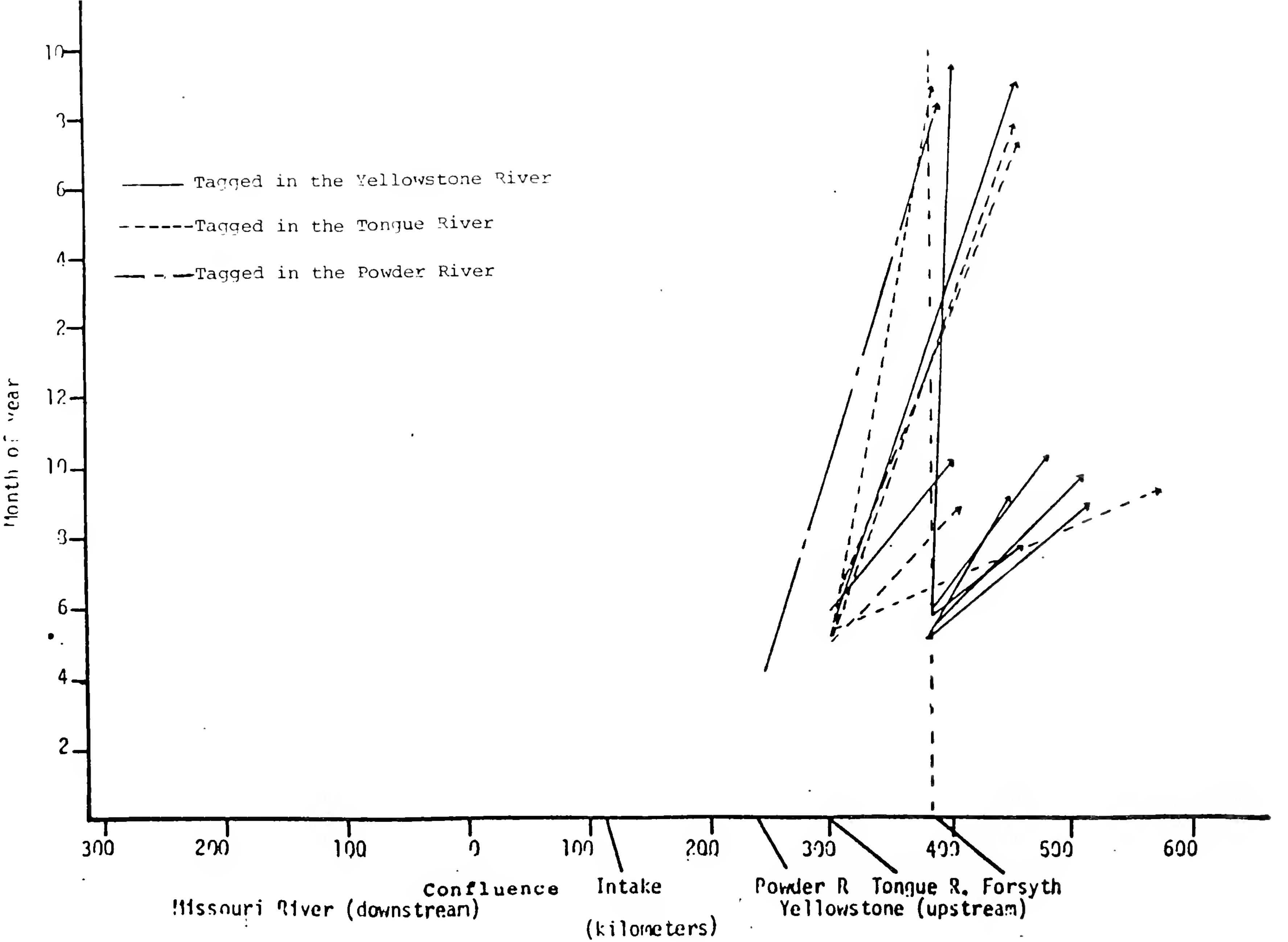

Figure 17. Sauger tagged in the Yellowstone, Tongue and Powder rivers from 1974-1979 and recaptured upstream from Forsyth diversion during the same or a consecutive year.

river location in subsequent autumns, as indicated by tag returns. Sauger were commonly recaptured during the same autumn tagged, near the captive site, while only 3 fall-tagged sauger were ever recaptured (including angler returns) at a different location the same fall. A sauger tagged in a Missouri River tributary on April 3, 1978 moved 460 km to the Yellowstone River near Miles City and was recaptured near Miles City on July 24, July 31, and November 11 of 1978.

Distribution of Eggs

An expansive submerged gravel bar which extends over 2 km downstream from Intake diversion was often occupied by large numbers of walleye and sauger during spring. During 1977 to 1979 large numbers of eggs were collected from the Intake gravel bar during April and early May. These eggs were positively identified as those of Stizostedion sp. by hatching them in aquaria. Larvae had characteristics of Stizostedion sp. described by Nelson (1968b) and Haugue et al. (1976). Both mature sauger and walleye have been collected at this location during spring. To identify eggs according to species, diameters of eggs collected from the Intake gravel bar and from ripe female walleye and sauger were measured to the nearest 0.01 mm during 1977, 1978, and 1979.

In 1978 diameters of 107 eggs from three ripe female walleye were measured. The diameters ranged from 1.80 to 2.35 mm with a mean diameter of 2.09 mm and a standard deviation of 0.143. Only 11 (10%) of the eggs had diameters of 1.90 mm or smaller. A one way T-test showed that the diameter of any one egg would be greater than 1.90 mm 90 percent of the time.

In 1978 and 1979 a total of 95 eggs were collected from four ripe sauger collected in the Yellowstone and Tongue rivers. The range of egg diameters was 1.60 mm to 2.00 mm with a mean of 1.78 mm and a standard deviation of 0.081. Only 4 (4%) of the eggs had diameters larger than 1.90 mm. A one way T-test showed that any one sauger egg would be 1.90 mm or smaller 93% of the time. Thus, to separate eggs according to species, eggs with diameters from 1.60 - 1.90 mm were considered to be sauger and from 1.91 to 2.40 mm were identified as walleye. This closely follows observations by Nelson (1968b) who noted that sauger and walleye egg diameters ranged from 1.44 - 1.86 mm and 1.90 - 2.31 mm, respectively. Diameters which had no overlap between species were less than 1.80 mm for sauger and greater than 2.00 mm for walleye, so eggs collected within these ranges were considered positive sauger and walleye eggs, respectively.

During 1977, diameters of 162 eggs from the Intake gravel bar were measured. Of these 4 were larger than 2.40 mm, did not have the appearance of <u>Stizostedion</u> sp. eggs, and were not included in the computations. Egg diameters ranged from 1.75 to 2.40 mm. Only 19 eggs (12%) were 1.90 mm or smaller indicating that a minority of eggs originated from sauger (Table 5). Only 6 eggs (4%) were smaller than 1.80 mm (positive sauger). Of the 139 eggs considered

Table 5. Diameters of *Stizostedion* sp. eggs collected in the Yellowstone River downstream from Intake diversion, 1977-1979. Percent of total is in parenthesis.

Year	Number Eggs	Mean Diameter	Standard Deviation	Number <1.90 mm (Sauger)	Number >1.90 mm (Walleye)	Number <1.80 (+Sauger)	Number >2.00 mm (+Walleye)
1979	120	2.14	0.098	3(2)	117 (98)	0	101 (84)
1978	161	2.21	0.126	2(1)	159 (99)	1 (1)	147 (91)
1977	158	2.11	0.145	19(12)	139 (88)	6 (4)	112 (71)

to be from walleye, 112 (71% of total number of eggs) were larger than 2.00 mm (positive walleye). The mean egg diameter was 2.11 mm with a 90 percent confidence interval for any one egg of 1.87-2.35 mm.

The date of maximum abundance of eggs, collected at 4 standard transects downstream from Intake diversion, was; April 18, 1977 (the first day of sampling), April 25, 1978 and May 1, 1979 (Figure 18). The peak egg abundance during 1977 corresponded to peaks in abundance of both male and female walleye and female sauger; male sauger were almost absent in the samples at this time. During 1979 peak egg numbers corresponded closely to peak male walleye numbers while sauger were at extremely low numbers.

The earliest date eggs were collected was April 11, 1978 and the latest was May 23, 1979. Eggs probably could have been collected up to 7 days earlier had sampling commenced sooner in 1977.

A gravel bar downstream from Forsyth diversion was kick sampled for sauger and walleye eggs during 1978. Eggs were sampled at 4 transects and samples were taken at 0.15 m depth intervals (Figure 19). In addition other likely locations were sampled (Figure 19).

Only one egg was collected in the 74 samples taken on April 12, 17 and 26. The egg, taken on April 12 was probably from a walleye as it was larger than 2.0 mm and a gravid female walleye was collected at this site. During this sample period large numbers of eggs were collected from the Yellowstone River at the

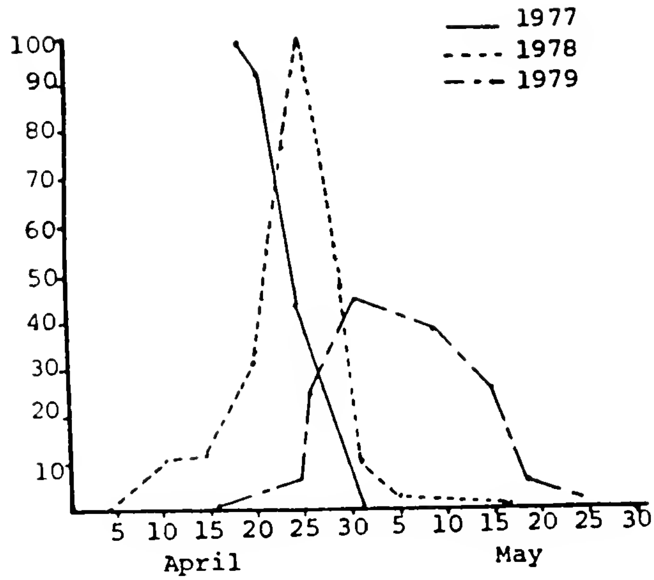

Figure 18. Number of Stizostedion sp. eggs collected on 4 transects of the Yellowstone River downstream from Intake diversion, 1977-1979.

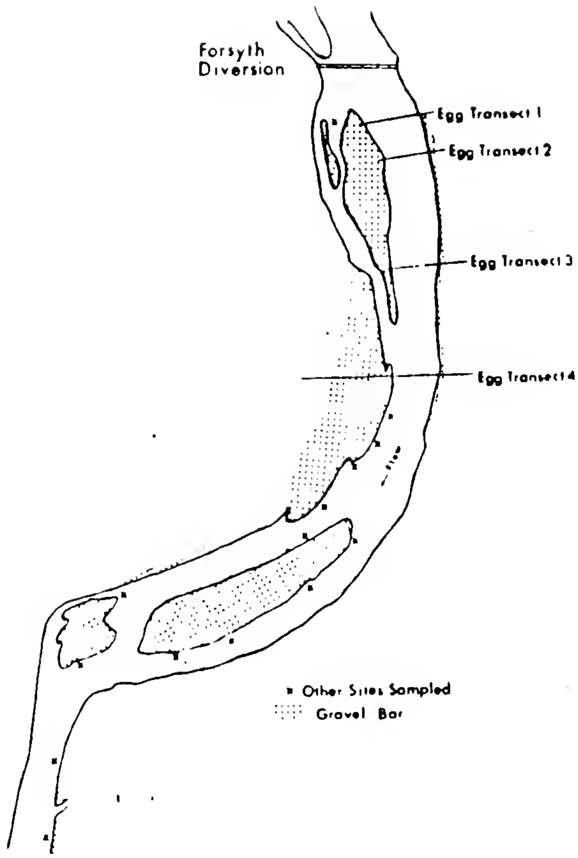

Figure 19. Map of egg transect sites downstream from Forsyth diversion.

gravel bar downstream from Intake diversion (Figure 18) and large numbers of sauger were present in the Tongue River (Figure 4) while few sauger were present in the Yellowstone downstream from Forsyth diversion (Figure 9).

Peterman and Haddix (1975) suggested that sauger were possibly spawning downstream from Forsyth dam in 1974. However, not having information on the chronology of the spawning run in the Tongue and Powder rivers or on movement patterns, they may have mistaken the return of mature sauger from spawning grounds in the tributaries as the spawning run itself. Their data indicates that sauger were not abundant at this location until late April in 1974.

While electrofishing the Yellowstone River at Miles City during 1979 two gravel bars downstream from the mouth of the Tongue River where ripe female sauger had been collected were kick sampled for eggs. Sampling was done on April 30, the day of peak male sauger numbers in the Tongue River (Figure 4) and of peak egg numbers at Intake (Figure 18). No eggs were found.

To locate spawning areas of sauger and walleye in the Yellowstone River from Miles City to North Dakota (272 km) this reach of river was electrofished and kicked sampled for eggs where concentrations of sauger and walleye were apparent. Sampling began on April 19, 1980, two days after collection of the first spent female sauger, and concluded on April 27, 1980. During this time, peak numbers of sauger were present in the Tongue and Powder rivers (Figure 4 and 5).

Mature sauger were generally collected singly, often with great distances separating individuals. On no occasion were large concentrations found which would typify a spawning ground. Sampling for eggs where several gravid females were found together produced no eggs. Never were more than 2 male sauger collected in close proximity to one another. From Intake diversion to North Dakota individual male sauger were often found associated with groups of male walleye.

Distribution of Prolarvae

A total of 84 and 10 sauger prolarvae were collected in the Tongue River near its mouth during 1979 and 1980, respectively. Thirteen sauger prolarvae were captured in the Powder River near its mouth in 1980. No larval sauger were collected in the Yellowstone River upstream from the Tongue River during 1979 or 1980. Sampling efficiency, however, is much lower in the Yellowstone than in the tributaries. A total of 8 sauger larvae were collected in the Yellowstone both upstream and downstream from Intake diversion during sampling in 1979 and 1980.

Distribution During Summer and Autumn of Young-of-Year

Thirty-four backwater/side channels were electrofished from river km 67 to 310 (Sidney to 12 km upstream from Tongue River) in search of young-of-year sauger and walleye. Sampling occurred from August 5 to 11, 1980. A total of 26 young-of-year sauger were collected; 24 from the two downstream most backwaters sampled, river km 68 and 70 (Table 6). One young-of-year sauger was collected 2.8 km downstream from Intake diversion (river km 114)

Table 6. Number of young-of-year sauger captured by electrofishing in 34 backwaters and side channels during August 5-11, 1980 and a description of the same sites.

Sec. No.	River Km	Length of Sec	Description of section	No. YOY sauger	No/km sampled	Range of total length mm
1	67.9	2.6	Long narrow side channel with a slight current, sauger caught in pools and small riffles.	18	6.9	138-199
2	70.0	2.3	Small side channel, sauger caught in slack pools of inside bends.	6	2.6	158-198
3	93.5	0.2	Pool at base of slightly flowing side channel.	0	-	-
4	98.2	0.8	Pool at base of dry side channel.	0	0	-
5	103.2	0.6	Small side channel with deep pools below riffles.	0	0	-
6	104.6	0.5	Pool at base of dry side channel.	0	0	-
7	107.8	0.2	Pool at base of dry side channel.	0	0	-
8	111.5	0.3	Side channel run and pool along gravel bar.	1	3.3	181
9	112.0	0.3	Side channel run and pool along gravel bar.	0	0	-
10	141.8	1.0	Small side channel with riffles and pools.	0	0	-
11	144.5	1.0	Small side channel with riffles and pools.	1	1	192
12	146.9	0.1	Pool at base of dry side channel.	0	0	-

Table 6 continued.

Sec. No.	River Km	Length of Sec	Description of section	No. YOY Sauger	No/km Sampled	Range of total Length mm
13	197.5	4.8	Main channel pools and slow runs.	0	0	-
14	198.6	0.2	Pool at base of small side channel.	0	0	-
15	199.0	0.2	Side channel along small gravel bar, pools and runs.	0	0	-
16	206.3	0.8	Side channel with pools and runs along gravel bar.	0	0	-
17	229.3	1.8	Moderate side channel with riffles, runs, pools, and eddies.	0	0	-
18	236.4	0.5	Small side channel along gravel bar with riffles, runs, and pools.	0	0	-
19	240.6	2.4	Main channel runs and pools downstream from the mouth of the Powder River.	0	0	-
20	241.0	0.3	Pool at head of very moderately flowing backwater.	0	0	-
21	243.5	0.5	Slightly flowing side channel with a large pool.	0	0	-
22	246.2	1.0	Side channel along gravel bar with long pool	0	0	-

Table 6 continued.

Sec. No.	River Km	Length of Sec	Description of section	No. YOY Sauger	No/km Sampled	Range of total Length mm
23	282.8	0.3	Pool at base of dry side channel.	0	0	-
24	286.0	0.8	Small side channel with pools and riffles.	0	0	-
25	292.9	1.0	Small side channel with slow riffles, runs, and pools.	0	0	-
26	296.8	0.8	Main channel pools and runs downstream from Tongue River.	0	0	-
27	298.2	0.8	Small side channels with pools, runs and riffles.	0	0	-
28	298.9	0.2	Slack water along gravel bar in main channel.	0	0	-
29	303.8	1.0	Moderate side channel with riffles and slow runs.	0	0	-
30	305.3	1.0	Small side channel with runs and pools.	0	0	-
31	306.1	0.6	Large pools in side channel with very little flow.	0	0	-
32	307.4	0.3	Pools along gravel bars in main channel.	0	0	-
33	309.0	0.8	Small side channel with runs and pools.	0	0	-
34	310.0	0.5	Backwater at base of dry side channel.	0	0	-

and only one was collected upstream from Intake diversion (river km 145). The largest number of sauger collected from one backwater was 18. This was a long narrow side channel with a small current and many pools, located adjacent to Seven Sister's Island (river km 67.9). The lengths of young-of-year sauger ranged from 138-199 mm. The two sauger collected furthest upstream were two of the larger specimens captured, 181 and 192 mm, respectively.

The fact that: 1) no young-of-year sauger were captured upstream from Glendive (river km 145) and 2) most young-of-year were collected from the lower reaches of the Yellowstone River (river km 70) suggests that the river current washes sauger larvae many miles downstream after hatching. Most larvae probably drift to areas near the mouth of the Yellowstone or even into the Missouri River (Garrison Reservoir). Nelson (1968a) observed that larvae which hatched in the Missouri River below Fort Randall Dam drifted over 70 km into Lewis and Clark Reservoir. Priegel (1970) discovered a large spawning marsh 156 km upstream from Lake Winnebago on the Wolf River and documented downstream movement of fry, probably into Lake Winnebago.

Behavior patterns of sauger larvae make them very susceptible to long distance drift. Priegel (1970) observed that walleye fry began vertical swimming movement from the time of hatching until developing fins allowed horizontal movement at age 10 days. Fry would sink in the water column and then with vigorous motion of the tail swim to the surface. Priegal found walleye fry drifting in the swiftest portion of the Wolf River (near mid-river in the upper one meter of water). Observations of sauger fry collected from the Yellowstone River system were similar.

Young-of-year sauger were not collected in the Yellowstone river near Miles City (river km 298) with electrofishing gear until November 4, October 26, and September 18 during 1977, 1978 and 1979, respectively. Only in 1979 were young-of-year sauger collected as far upstream as Forsyth diversion (river km 381). They were first collected at this site on October 4, 16 days after they were collected near Miles City. No young-of-year sauger were collected upstream from Forsyth diversion.

Young-of-year sauger were almost always present in the Yellowstone River downstream from Intake diversion on the first day of summer or fall electrofishing. Young-of-year were collected as early as July 12 during 1977 downstream from Intake diversion.

Gardner and Berg (1980) and Stewart (1980) found similar downstream concentrations of young-of-year sauger in two separate reaches of the Missouri River.

Young-of-year for many species of fish were most abundant in backwaters of the Yellowstone from Intake diversion downstream indicating the distribution of many and perhaps most fish species in the lower Yellowstone is affected by larval drift.

Distribution of Immature Sauger During Spring

During May 2 and 3, 1979 the Yellowstone River from Forsyth to Miles City was electrofished (84 river kilometers). Only 9 immature sauger were collected.

One hundred and fifty immature sauger were collected while electrofishing the Yellowstone River from Miles City to the North Dakota border (272 river km) during April 19 to 27, 1980 (Figure 20). The largest number of immature sauger for 8 km of river were collected downstream from Intake diversion, approximately three times the numbers in any other section. The next largest abundance occurred between Glendive and Intake diversion. From Glendive to 8 kilometers downstream from Intake, 15 percent of the river sampled, 74 immature sauger were collected representing 49 percent of the immature sauger collected.

Size and Age Distribution During Autumn

Fifteen sample stations on the Yellowstone River were electrofished from Huntley to the North Dakota border during autumn 1977 to 1979. These approximately 8 km long stations were lumped into 4 river sections (Figure 3) and analyzed accordingly.

Mean length for each year class of sauger in sections 1 through 3 of the Yellowstone River were very similar during fall of 1977 through 1979 (Table 7). Even though growth in these 3 areas of the Yellowstone River was similar, grand mean length of all sauger collected in section 1 was significantly smaller all 3 years than the mean lengths of sauger in sections 2 and 3. This can be attributed to the fact that a greater proportion of the sample in section 1 comprised younger (and thus smaller) fish (Table 8). Grand mean length of sauger collected in sections 2 and 3 were similar in samples from 1977 and 1978 while grand mean length was significantly greater in section 3 than 2 during 1979.

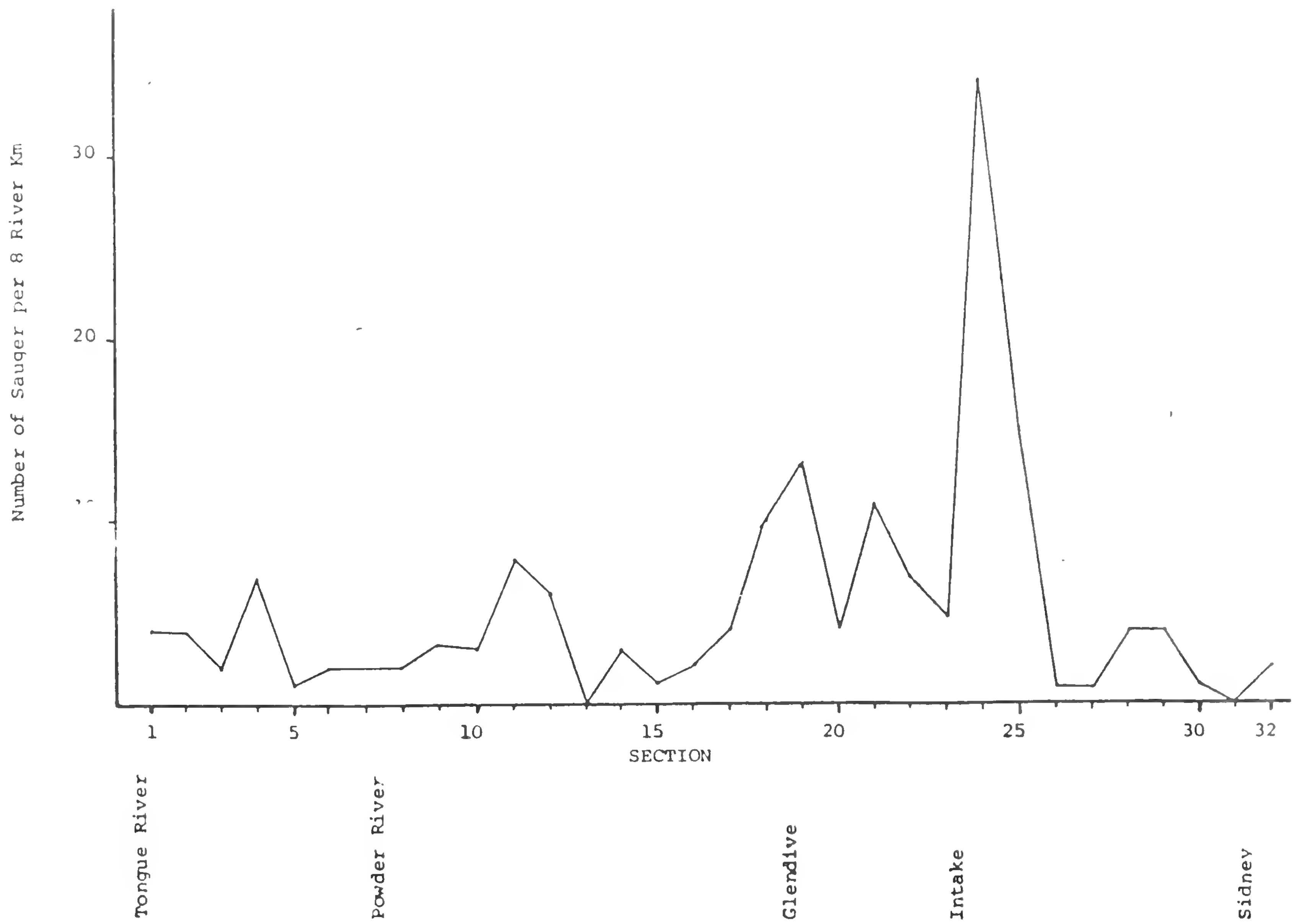

Figure 20. Electrofishing catch rates for immature sauger captured in 8 km sections of the Yellowstone River from Miles City to North, Dakota, April 19-27, 1980.

Table 7. Mean length (mm) of each year class of sauger collected in four sections of the Yellowstone River, autumn, 1977-1979.

	1977 Section				1978 Section				1979 Section			
	1	2	3	4	1	2	3	4	1	2	3	4
0+	-	-	-	-	189	183	-	-	184	178	170	-
1+	235	261	260	292	252	242	262	364	233	254	277	-
2+	304	309	305	-	292	292	316	355	278	293	313	370
3+	339	349	342	381	341	344	364	415	321	344	347	417
4+	392	392	380	418	408	386	399	454	368	381	392	460
5+	447	445	452	469	465	429	449	483	459	418	425	500
6+	551	493	473	531	-	489	473	522	435	475	466	532
7+	-		591	559	-	-	587	523	-	-	549	-
8+	-	-	-	-	-	-	-	-	-	-	498	-
Grand	318[c]	341[a,e]	348[a]	415[f]	296[c]	339[b,d]	345[b]	440[f]	277[c]	314[d,e]	343	470[f]
Sample Size	326	168	430	41	244	317	564	79	176	162	1054	49
Standard deviation	77.3	73.2	64.7	83.4	60.3	81.1	70.9	85.0	64.8	81.1	70.4	77.8

a & b Grand mean lengths with the same superscript for different sections within the same year are not significantly different (the remainder are significantly different).

c, d, e, & f Grand mean lengths with the same superscript for the same section within different years are significantly different (the remainder are not significantly different).

Table 8. Sauger year class composition (percent) in electrofishing samples from four sections of the Yellowstone River, autumn, 1977-1979.

	1977 Section				1978 Section				1979 Section			
	1	2	3	4	1	2	3	4	1	2	3	4
0+	0.4	0.6	0.3	0	3	4	1	0	9	12	4	0
1+	22	22	12	5	32	11	22	9	25	19	12	0
2+	33	19	17	0	40	26	22	17	41	25	29	18
3+	33	34	41	38	17	25	29	11	15	21	24	14
4+	5	12	19	26	7	18	17	30	6	14	18	12
5+	6	9	7	23	1	10	6	16	2	5	9	27
6+	1	3	2	8	0.4	5	2	12	1	4	3	27
7+	0	1	2	0	0	0.3	1	4	0	0	0.5	0
8+	0	0	0	0	0	0.3	0	1	0	0.6	0.3	2
Sample Size	326	168	430	41	244	317	564	79	176	162	1054	49

Sauger upstream from Forsyth dam (section 4) were consistently larger than the same age fish downstream (Table 7). Grand mean lengths of sauger collected in section 4 were significantly larger than grand means for all three other sections all three years. The sample in section 4 was composed mostly of older fish with only a few yearlings collected and no young-of-year (Table 8).

The fact that the sauger population was much older and of larger mean length in section 4 than all other areas downstream (Table 7 and 8) may have been due to size selective passage over Forsyth diversion. Small fish may have a more difficult time negotiating this structure than larger sauger.

Catch Rates and Relative Abundance During Autumn

Fifteen sample stations on the Yellowstone River were electrofished from Huntley to the North Dakota border during autumn, 1977 to 1979. These approximately 8 km long stations were lumped into 4 river sections (Figure 3) and analyzed accordingly. Three to 8 times more sauger were captured in the 3 sections downstream from Forsyth diversion (sections 1 through 3) than in section 4, upstream from Forsyth diversion, during the 3 years of sampling (Table 9). This may be due to Forsyth diversion acting as a partial barrier to sauger migrating upstream. The number of sauger collected per 8 river km were very similar in the middle 2 sections (sections 2 and 3) each year. The number of sauger collected in the downstream most section (section 1) was slightly lower than that in sections 2 and 3 in 1978 and 1979 but slightly greatly in 1977.

Table 9. Average number of sauger (SRG) and walleye (WE) collected per 8 km of river electrofished during late summer and fall in four sections of the Yellowstone River.

Section (River km)	1977 n[a]	1977 WE	1977 SGR	1978 n	1978 WE	1978 SGR	1979 n	1979 WE	1979 SGR
1. Sidney-Intake Dam (56-114)	6	2 (1-3)[b]	39 (23-55)	6	4 (0-12)	36 (12-61)	4	2 (0-4)	43 (35-50)
2. Intake Dam-Powder River (114-233)	6	0.5 (0-1)	28 (11-45)	6	0.8 (0-1.8)	55 (31-78)	3	0.7	54 (18-101)
3. Powder River-Forsyth Dam (233-381)	10	0.6 (0.2)	24 (14-34)	10	0.9 (0.2-1.6)	59 (42-76)	16	3 (1-5)	52 (43-73)
4. Forsyth Dam - Huntley (381-575)	7	0.0	6 (3-8)	8	0.1 (-)	7 (2-12)	4	0.3 (-)	14 (2-27)

[a] Number of stations sampled
[b] 95% confidence interval

Population Statistics of Sauger at Miles City During Autumn

As previously discussed, sauger were sedentary during late summer and fall, allowing population size to be measured by mark-recapture techniques. Estimates of the late summer/fall sauger population in an 8 km reach of the Yellowstone River near the mouth of Tongue River (Figure 1) were obtained during 1978 through 1980. A total of 524, 504, and 400 age 1+ and older sauger were marked during each of the respective years. The number of sauger recaptured during the experiment was 38, 46, and 30 in 1978, 1979, and 1980, respectively.

Sauger were significantly most abundant in 1978 and least abundant in 1979 (Table 10). Sauger numbers estimated ranged from 177 to 247 per kilometer in the three years. Sauger apparently enter the population at Miles City in large numbers at age 2+. Over 30 percent of the 1978 and 1979 population was comprised of age 2+ sauger.

Angler Harvest

A total of 11,499 sauger were tagged from 1974 through 1980 and during this time 425 were recaptured by fishermen, giving an annual average harvest rate of less than one percent. The present harvest rate probably has little impact on the sauger population in the lower Yellowstone River.

Table 10. Age, number and biomass structure of sauger in an 8 km section of the Yellowstone River at miles City, fall,1978-1979.

	1978				1979				1980
Age	Number	%	(kg) Weight	%	Number	%	Weight	%	Number
1+	346	17	68	11	181	13	34	7	Sauger not yet aged
2+	675	34	179	27	467	33	111	24	
3+	607	31	218	34	389	28	132	28	
4+	253	13	108	17	276	20	123	26	
5+	70	4	48	7	86	6	48	10	
6+	24	1	20	3	12	1	11	3	
7+	6	0	9	1	3	0	5	1	
8+	0	-	0	0	2	0	2	0	
Total	1981[a]		650		1416[a,b]		466		(Preliminary estimate) 1809[a]
Confidence Interval 95%	(1576-2666)		(517-875)		(1147-1850)		(377-608)		(1743-1880)

[a] Significantly different at p<.01
[b] Significantly different at p<0.10

Life History and Population Statistics of Walleye

Relative Abundance and Sex Ratios

A total of 155 walleye were captured at sampling stations in the Yellowstone River drainage upstream from Intake diversion during March-May, 1976-1980 (Table 11). This represents only 3 percent of the combined walleye-sauger catch in this reach of river

Table 11. Number and (percent) by sex of walleye captured in the Yellowstone River drainage, March - May, 1976-1980.

		Sex (Percent)		
Location	Number Captured	Males	Females	Immature or Undetermined
Tongue River	85	69(81)	4(5)	12(14)
Powder River	9	7(78)	1(11)	1(11)
Yellowstone River at:				
Forsyth	21	9(43)	8(38)	4(19)
Miles City	30	14(47)	5(17)	11(36)
Mouth Powder River	10	6(60)	2(20)	2(20)
Intake	1940	1744(90)	139(7)	57(3)

system (Table 2). The majority of walleye were mature; 68, 13, and 19 percent were males, females and immature, respectively. Walleye never exceeded 4 percent of the combined catch of mature walleye and sauger in the Tongue or Powder rivers during spring.

During the spring of 1980, one side of the Yellowstone River was electrofished from Miles City to the North Dakota border (272 river km). Walleye were first captured consistently beginning at section 11 downstream from Terry, Montana (river km 222) while 78 percent of all mature walleye were captured in the reach from Intake diversion to the North Dakota border (Figure 21). The greatest number of walleye were captured in section 24, immediately downstream from Intake only during spring. Walleye comprised 73 percent of the combined catch (420 fish) of all mature walleye and sauger captured on this electrofishing run (Table 12). Considering the Yellowstone River as a whole, sauger are much more abundant than walleye.

During any one year walleye comprised 50 to 89 percent of the total number of mature walleye and sauger caught downstream from Intake diversion dam during March - May 1976-1980. Walleye averaged 76 percent of the catch for all 5 years (Table 13). Female walleye averaged 48 percent of the combined catch of female sauger and walleye sampled while male walleye averaged 79 percent of the catch of males for the two species. Walleye used the gravel bar downstream from Intake extensively for spawning, while sauger, although at times abundant, tended to spawn at other locations (see

Table 12. Number of sauger and walleye, by sex, collected in the Yellowstone River from Miles City to North Dakota, April 19-27, 1980.

	SAUGER						WALLEYE					
	Female				Male		Female				Male	
	Hard	Ripe	Spent	Total	Ripe	Total	Hard	Ripe	Spent	Total	Ripe	Total
Upstream from Intake Dam	42	0	16	58	33	91	10	1	1	12	55	67
Downstream from Intake Dam	12	0	3	15	10	25	11	2	1	14	223	237
Total	54	0	19	73	43	116	21	3	2	26(27)[a]	278(87)	304(73)

[a] Numbers in parenthesis are percentage of walleye in the combined walleye-sauger catch.

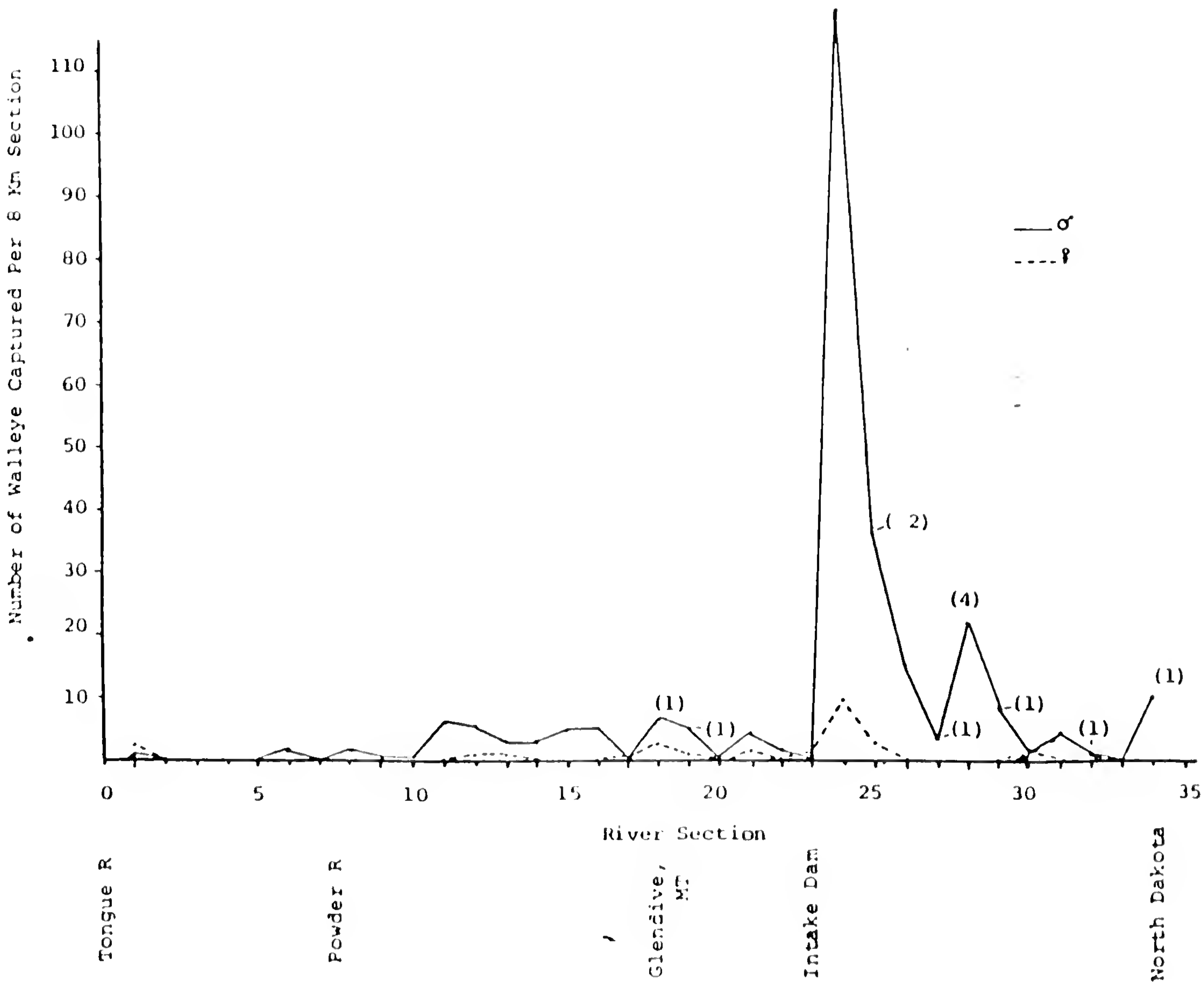

Figure 21. Electrofishing catch rates for mature walleye captured in 8 km sections of the Yellowstone River from Miles City to North Dakota, April 19-27, 1980. The number of spawning grounds in each section is in parentheses.

Table 13. Number of sauger and walleye, by sex, collected in the Yellowstone River downstream from Intake Diversion, April-May, 1976-1980.

	SAUGER						WALLEYE					
	Female				Male		Female				Male	
	Hard	Ripe	Spent	Total	Ripe	Total	Hard	Ripe	Spent	Total	Ripe	Total
1980	41	2	9	72	76	128	21	3	3	27(34)[a]	277(78)	304(70)
1979	2	0	3	5	32	37	5	5	1	11(69)	128(78)	139(79)
1978	14	2	8	24	82	106	45	3	4	52(68)	836(91)	888(89)
1977	12	0	8	20	181	201	11	2	2	15(43)	184(48)	199(50)
1976	39	1	11	51	83	134	30	1	3	34(40)	319(79)	353(72)
Total	108	5	39	152	454	606	112	14	13	139(48)	1744(79)	1883(76)

[a] Percent of walleye in the combined walleye-sauger catch.

Life History and Population Statistics of Sauger). The maximum sample size of male walleye on any one day was 55.7 fish/km which compares to 13.5 males/km for sauger. The maximum sample size of female walleye and sauger on any one day was 6.5 and 7.3 fish/km, respectively.

Priegel (1970) found male walleye comprised 70 (2.3 males:1 female) to 98% (49 males:1 female) of the mature walleye captured on tributary spawning marshes to Lake Winnebago, Wisconsin. The sex ratio for all walleye collected at Intake during any one year ranged from 9:1 to 16:1 while the ratio on any one day ranged from 2:1 to 73:1. Priegel (1970) attributed the observed dominance of males on the spawning grounds to two factors: 1) males arrived earlier on the grounds and remained throughout most of the spawning season, and 2) males began to mature at age 3 while females were not first mature until age five. This is very similar to observations on the lower Yellowstone.

Recapture Rate and Movement

Of the 155 walleye tagged at sample sites in the Yellowstone River system upstream from Intake diversion, 7 (5%) were recaptured at the same site during spring of the same year (Table 14). Five of these were recaptured in the Tongue River. Only 2 (1%) were recaptured during spring of a subsequent year at the site of tagging (Tongue River).

A total of 168 walleye were tagged and recaptured the same spring at Intake; 8.0 percent of the total number of walleye captured (Table 15).

Walleye demonstrated a high return rate to Intake in subsequent springs (Table 16). In 1979, 9% of the walleye captured (excluding same year recaptures) were tagged at Intake the previous year. It is estimated that 33% of the spawning walleye population at Intake was tagged in 1978. This suggests that of the walleye present at Intake during the spring of 1979, 27% were present at this same location during the previous spring. This is a high incidence of return especially considering that neither recruitment nor mortality is accounted for in these figures.

Most of the walleye tagged at Intake during spring migrated downstream into Garrison Reservoir immediately after the spawning period. Of the 53 walleye tagged at Intake and recaptured the same year during a different season or at a different location, 87, 2, and 11 percent were collected downstream, near, and upstream from the tag site, respectively (Figure 22).

Ninety-eight walleye were recaptured in subsequent years after being tagged downstream from Intake diversion (Figure 23), 76 (78%) of which were recaptured downstream an average distance of 168 river km while 5 (5%) moved upstream, all of which were caught in

Table 14. Number of walleye tagged and number recaptured at the same site, spring, 1976-1980.

Location	Number Tagged	Recaptured during spring of: Same year	Subsequent Year
Tongue River	85	5	2
Powder River	9	0	0
Yellowstone River at:			
Forsyth	21	1	0
Miles City	30	1	0
Mouth of Powder River	10	0	0
Intake	1940	168	63

Table 15. Total number of walleye captured and number recaptured the same spring downstream from Intake diversion.

Year	Total Number Caught (C)	Recaptured the same year: Number (R)	Percent (100X(R/C)
1980	319	3	0.9
1979	149	2	1.3
1978	1033	143	13.8
1977	215	6	2.8
1976	392	14	3.6
Total	2108	168	8.0

or near the Tongue River (185 river km upstream). The large number of walleye recaptured at Intake in a subsequent spring suggests that walleye home to this spawning area.

Overall, 6 times more walleye tagged at Intake were recaptured downstream than upstream. The average recapture distance downstream and upstream was 207 and 160 km, respectively (Table 17).

The vast majority of walleye present at Intake in spring are residents of Garrison Reservoir in North Dakota. The tag returns from this area were fish caught by anglers.

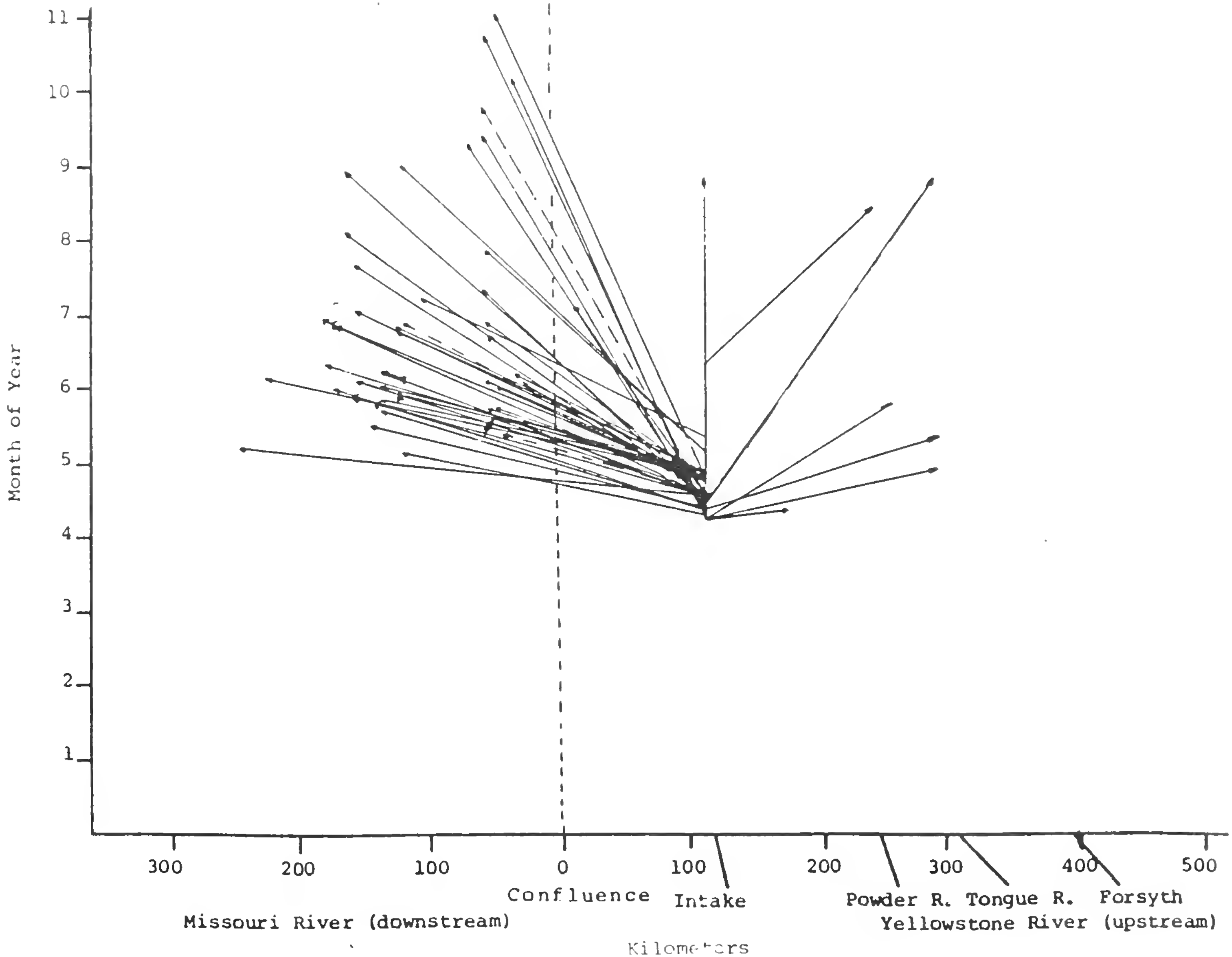

Figure 22. Movement of walleye tagged downstream from Intake diversion, 1974-1980 and recaptured in the Yellowstone River, Garrison Reservoir, N.D. or Missouri River (---) upstream within the same

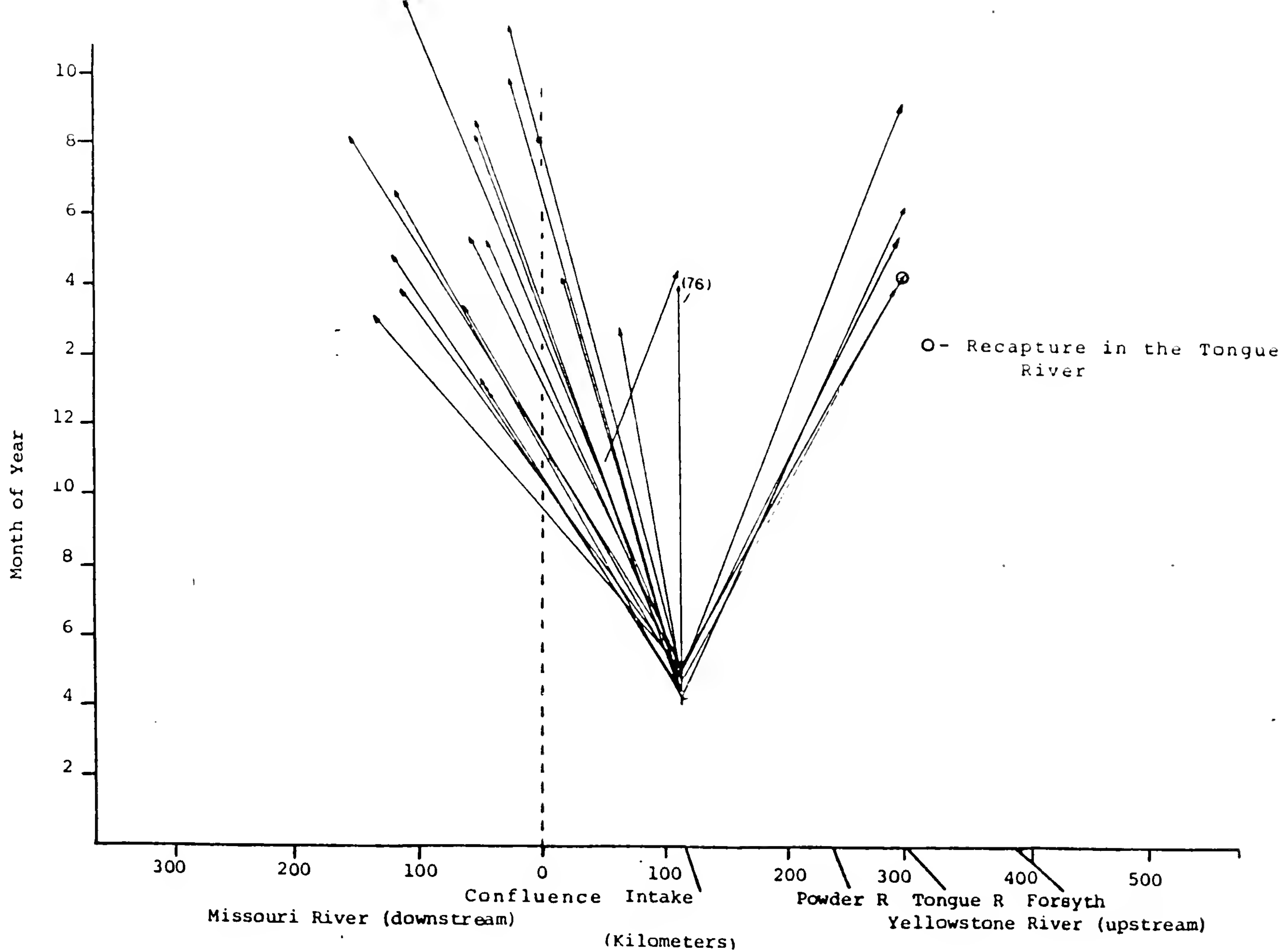

Figure 23. Movement of walleye tagged downstream from Intake diversion, 1974-1979 and recaptured in the Yellowstone River, Garrison Reservoir, N.D., or Tongue River in a later year.

Table 16. Number of walleye recaptured by electrofishing downstream from Intake diversion, spring, 1976-1980.

Year	Fish tagged at Intake	Number of recaptured fish fish tagged at other locations	Number of recaptures from fish tagged in previous spring at Intake	Total	Number of walleye caught which were tagged at Intake during; 1979	1978	1977	1976
1980	309	0	7	316	3(1)[a]	4(1)	0	0
1979	130	0	17	147	-	13(9)	2(1)	2(1)
1978	855	2	34	890	-	-	16(2)	18(2)
1977	204	0	5	209	-	-	-	5(2)
1976	378	-	-	378	-	-	-	-
Total			63(3)	1940				

[a] Percent of total new fish tagged is in parenthesis.

Only 18 walleye tagged at other locations in the Yellowstone were recaptured. Most of those tagged upstream from Intake dam were recaptured at the same location or moved downstream (Table 17).

Spawning Sites

Haddix and Estes (1976) discovered that walleye and sauger were spawning over an extensive gravel bar downstream from Intake diversion during 1975 and 1976. Graham et al. 1979) also documented that walleye and sauger were using this location for reproduction in 1977. Graham et al. (1979) also sampled sites downstream from Intake but found only one Stizostedion sp. egg. One side of the Yellowstone was electrofished from Forsyth to the North Dakota border to find other spawning sites.

The 84 km reach from Forsyth to Miles City was electrofished during May 2-3, 1979 and no spawning sites were found. Only 1 mature sauger and no walleye were collected. The reach from Miles City to the North Dakota border was electrofished from April 19 to 27, 1980. A total of 15 probable spawning sites for walleye were identified; two upstream from Intake diversion and 13 downstream (Figure 24). A spawning area was identified by the presence of a large number of males and the presence of eggs (Table 18). The two sites upstream from Intake diversion were both upstream from Glendive, river km 163 and 154.

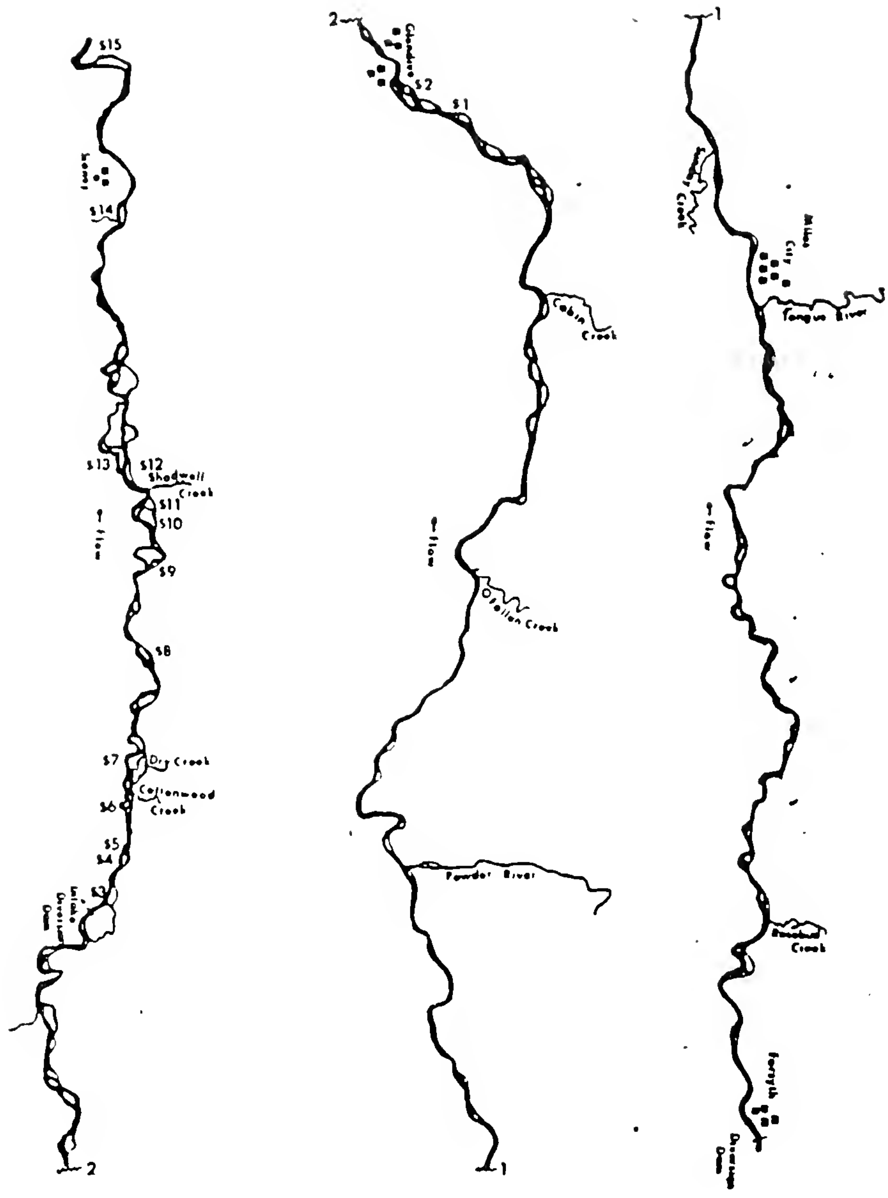

Figure 24. Location of probable walleye spawning sites (s) in the lower Yellowstone River.

Table 17. Summary of walleye tag returns and mean distance moved (d) in the Yellowstone River system, 1974-1980.

Tagging location	Total No. recaptured	Downstream		Upstream		Same location
		%	d(km)	%	d(km)	%
Mouth Yellowstone R. to 8 km downstream Intake Dam	6	50	85	50	133	0
8 km downstream Intake Dam to Intake Dam	151	42	207	7	160	51
Intake Dam to 8 km downstream Powder R.	3	67	169	33	93	0
Yellowstone R. near mouth Tongue R.	0					
Powder River	0					
Yellowstone R. near mouth Tongue R.	6	0	-	0	-	100
Tongue R.	4	25	242	0	-	75
Yellowstone R. - Forsyth	2	50	84	0	-	50
Yellowstone R. - Forsyth Dam upstream	0					

Table 18. Description of probable walleye spawning sites located in the Yellowstone River, 1980.

Spawn Site No.	River Km	Nearest Landmark	Location of Site	Observations	No. egg/kick	Egg Kick Samples Depth (cm)	Velocity (cm/s)	Substrate
1	163	East Sand Cr(R)	Riffle along rt. bank gravel bar at head of dry side channel	Many male & 1 soft female in 1 group	-	-	-	-
2	154.5	Upper 7 Mi Cr.(L)	Riffle along gravel island	Many male & 1 soft female congregated	-	-	-	-
3	114.3	Intake	Run over gravel bar below dam	Dense concentrations or male ripe, soft female	18	-	-	Cobble
4	109.8	Linden Cr (L)	Run over gravel at base dry channel	Many male, soft female	-	-	-	-
5	108.8	Linden Cr (L)	Run over gravel at base dry channel	Many male, soft female	-	-	-	-
6	104.0	Cottonwood Cr (R)	Gravely run at head at side channel	Many male	3	91	76	Pebble-cobble
7	98.3	Dry Cr. (R)	Gravely run at head of dry side channel	Many male	4	91	82	Cobble
8	87.9	Smith Cr. (R)	Gravely run at head of dry side channel	Many male	6	91	134	Cobble

Table 18 continued.

Spawn Site No.	River Km	Nearest Landmark	Location of Site	Observations	No. egg/kick	Egg Kick Samples Depth (cm)	Velocity (cm/s)	Substrate
9	81.1	Smith Cr (R)	Riffle along gravel island	Many male	9	76	91	Cobble
10	76.0	Shadwell Cr. (R)	Run along gravel island above head of side channel	Many male	13	61	94	Pebble-cobble
11	73.5	Shadwell Cr. (R)	Run near cliffs in side channel	Many male	27	91	91	Fine-Pebble
12	71.9	Shadwell Cr. (R)	Run at head of dry side channel	Many male	17	61	110	Cobble
13	71.1	Shadwell Cr. (R)	Run upstream from dry channel	Several male	-	-	-	-
14	44.3	Lone Tree Cr. (L)	Side channel run near mouth Cr.	Several male	3	61	100	Pebble
15	26.4	First Hay Cr. (L)	Inside bank of sharp bend in river	Many male	3	91	79	Boulder

The largest number of walleye spawning areas, 11, were located between river km 114 (Intake diversion) and 71 (40 km upstream from Sidney). The mean distance between sites in this section was 4.3 km. Only one site was located downstream from Sidney (river km 71) (Figure 24).

Eleven of these 15 walleye spawning sites were in gravely runs at the head or mouth of dry side channels or along gravel islands (Table 18). The four other sites where eggs were found were: 1) an extensive gravel bar downstream from Intake diversion, 2) a run along a cliff, 3) at the mouth of a creek, and 4) at a sharp bend in the Yellowstone River. All sites were dominated by a pebble or cobble substrate. The spawning ground downstream from Intake diversion was the largest and had many more walleye at the site than all other spawning areas.

Distribution of Immature Walleye During Spring

No immature walleye were collected while electrofishing the Yellowstone River from Forsyth to Miles City during May 2 to 3, 1979. Sixteen immature walleye were collected while shocking one side of the Yellowstone River from Miles City to the North Dakota border during April 19-27, 1980. This represents 10% of the combined catch of immature walleye and sauger. Fifty percent of the immature walleye were captured upstream from Intake diversion and 50% downstream. Very few, 3%, of the 1940 walleye captured (excluding same year recaptures) at Intake during spring of 1976-1980 were immature (Table 11).

No young-of-year walleye were collected in the Yellowstone River or its tributaries. This suggests that virtually all walleye larvae produced in the Yellowstone River system drift downstream into the Missouri River (Garrison Reservoir). Priegel (1970) documented that walleye fry drifted downstream in tributary streams, probably 150 or more km, to reach Lake Winnebago. The spawning area 163 km upstream from the mouth of the Yellowstone is the uppermost walleye spawning ground found (Table 18).

Age, Growth, and Population Statistics During Spring

The mean length and weight for the walleye spawning population at Intake in spring 1978 was 414 mm and 656 g for males and 517 mm and 1354 g for females. The youngest mature males collected were age 2 but were not abundant in the population until age 5 (Table 19). Females did not appear in the population until age 5. Age 6 walleye comprised over 40% of the population of both males and females. The mean length of age 3 walleye was 358 mm and length increased an average of 30 mm for each successive year in age (Table 20).

Table 19. Age structure of the spawning walleye population downstream from Intake diversion, spring, 1978[a].

Age	2	3	4	5	6	7	8	9	10
Males									
% of Total	0	7	17	23	44	5	3	1	0
Females									
% of Total	0	0	0	14	41	23	14	9	0

[a] Based on scales examined from 835 fish.

Table 20. Mean length and weight at annulus of walleye collected downstream from Intake diversion, spring, 1978.

Age	Number aged	Mean length	Mean weight
3	50	358	406
4	136	385	510
5	192	409	612
6	366	421	665
7	50	469	928
8	29	510	1199
9	11	499	1199
10	1	583	1320

Catch Rates and Relative Abundance During Autumn

Fifteen sample stations on the Yellowstone River were electrofished from Huntley to the North Dakota border during autumn, 1977-1979. These approximately 8 km long stations were lumped into 4 river sections (Figure 3) and analyzed accordingly. Large concentrations of walleye were observed in section 1 during 1977 and 1978. Slightly higher numbers were observed in section 3 than 1 in 1979. Section 4 had the lowest concentrations of walleye each year. In all sections walleye never comprised more than 10% of the walleye-sauger catch (Table 9).

An 8 km section of the Yellowstone River near the mouth of the Tongue River was intensively sampled during late summer and autumn, 1977-1980. The percent composition of walleye comprised 2.5, 3.2, 7.7, and 9.3 percent of the sample in 1977, 1978, 1979, and 1980, respectively. A total of 81, 555, 575, and 441 sauger and walleye combined were caught at this station each of the four respective years.

Importance of Yellowstone River Spawning to Garrison Reservoir

This spawning run is probably very important for recruitment of walleye into the upper portions of Garrison Reservoir where substrate may not be suitable for walleye reproduction. The upper area of the reservoir is more turbid and silty than the lower reservoir. Walleye usually select substrate characterized by clean rubble or gravel (Nelson and Walburg 1977, Scott and Crossman 1973). Survival of eggs is poor on a silt substrate (Johnson 1961). Berard (1980) documented that young-of-year walleye are most abundant in the upper third of Garrison Reservoir. Stewart (1980) found no large seasonal concentrations of walleye in the Missouri River upstream from the mouth of the Yellowstone indicating that the spawning run is limited to the Yellowstone River. Priegel (1970) documented that walleye fry drift into Lake Winnebago from spawning areas in tributaries. As no young-of-year walleye were ever collected in the Yellowstone River, it is assumed virtually all walleye larvae produced in the Yellowstone River drift into the Missouri River (Garrison Reservoir). Walleye larvae were collected in drift nets from the Yellowstone River downstream from Intake diversion (river km 112) and at Fairview (river km 19).

Immediately after spawning in the Yellowstone walleye return to Garrison Reservoir. Most walleye were recaptured by anglers in the upper one-third of Garrison Reservoir an average distance of 222 km downstream from their tagging location. The highest densities of adult walleye were found in the upper one-third of Garrison Reservoir (Berard 1980).

Homing to the Intake spawning area from one year to the next was high. Several studies have found evidence of homing behavior in walleye (Forney 1963, Cowe 1962, Olsen and Scidmore 1962). Olsen et al. (1978) hypothesized and Olsen and Scidmore (1962) provided evidence that homing behavior in walleye is learned. This tends to suggest that as walleye continue to spawn successfully in the lower Yellowstone River, spawning numbers should increase.

Angler Harvest

A total of 2,311 walleye were tagged from 1974 through 1980 and during this time 5 percent (108) were returned by fisherman; most were caught in Garrison Reservoir, North Dakota. The low rate of returns suggests that the harvest rate is not excessive.

Physical Requirements for Sauger and Walleye Reproduction

Intake

Spawning Critera

During April and early May of 1977, 1978, and 1979; 233, 238 and 148 Stizostedion sp. eggs were collected on the Intake gravel bar to determine sauger and walleye spawning criteria for depth, mean velocity (measured at 0.6 the depth) and substrate. Walleye and, to a much lesser degree, sauger were found spawning in the mainstem of the Yellowstone downstream from Intake diversion and the vast majority of eggs collected were determined to be from walleye (see Distribution of Eggs). The depths at which eggs were collected ranged from 30 to 107 cm (1.0 to 3.5 ft.). The minimum depth at which eggs were collected from the Intake gravel bar, 30 cm, was identical during each of the three years. In a lake environment walleye spawned at depths between 30 and 76 cm (Priegel 1970, Johnson 1961). Nelson (1968a) found sauger eggs at depths of 61 to 365 cm in the Missouri River.

Eggs were generally collected in deeper sites in 1977 and shallower sites in 1979 with 1978 intermediate (Figure 25). In 1977, 1978 and 1979; 71, 48, and 30 percent of the eggs, respectively, were collected in water 76 cm (2.5 ft) or deeper. Any one egg would be expected to occur in 46, 32, and 38 cm of water or deeper 90% of the time in 1977, 1978, and 1979, respectively. Since only depths up to 107 cm (3.5 ft.) could be sampled, upper limits could not be calculated.

The maximum velocity at which eggs would be expected to occur at a 90% confidence level was almost identical all three years, 94 to 96 cm/s (Table 21). Perhaps this is the maximum velocity at which walleye (sauger) can orient themselves during the spawning act and/or at which eggs do not get swept away.

Because the Yellowstone River carries large amounts of silt during periods of runoff, a clean cobble or pebble substrate is only present in areas with enough current to keep these fine

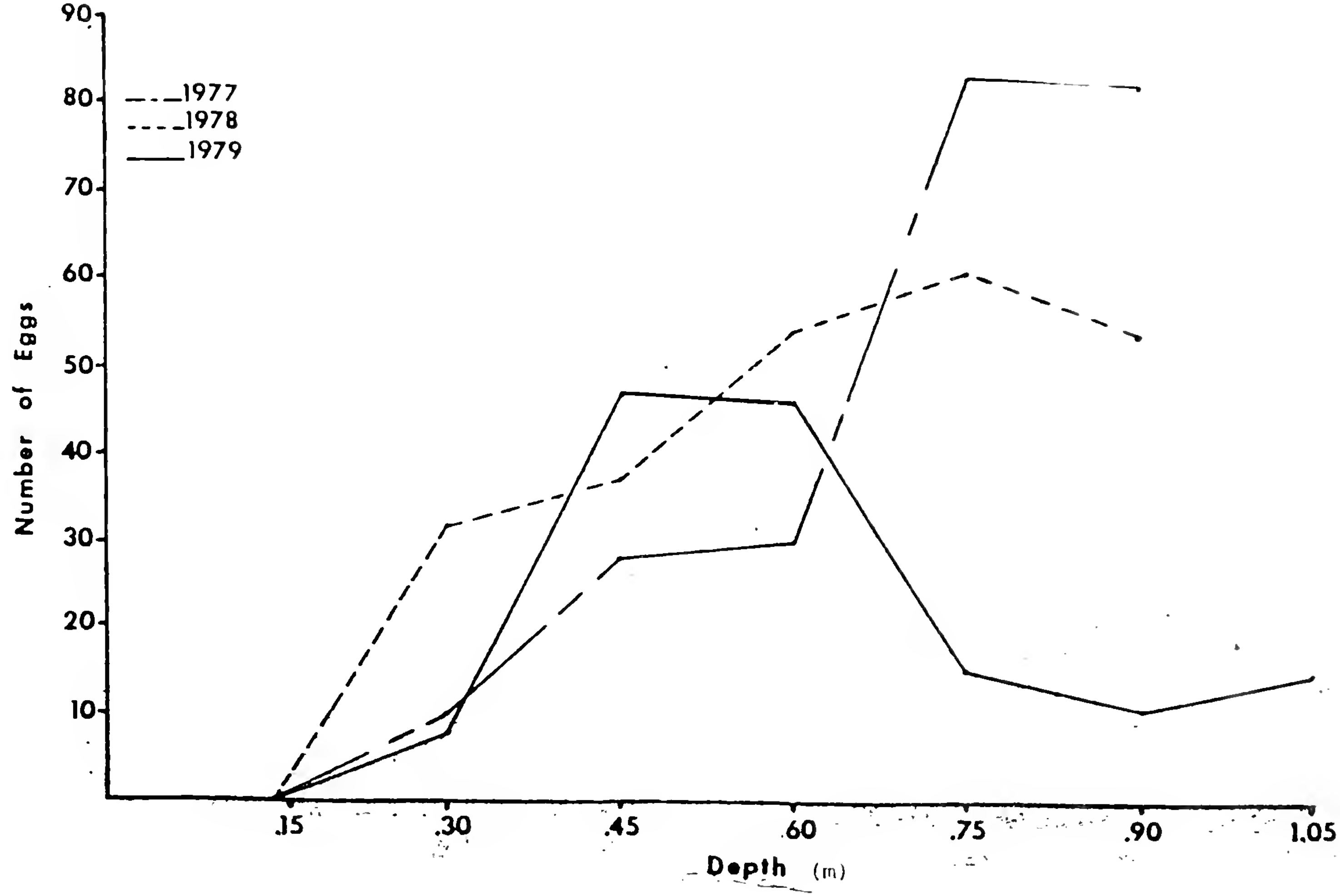

Figure 25. Total number of *Stizostedion* sp. eggs collected at 0.15 m depth intervals on the Intake gravel bar during 1977, 1978 and 1979.

materials suspended. The minimum water velocity where any one egg would be expected to occur on the Intake gravel bar (90% level of confidence) was 45 and 43 cm/s during 1978 and 1979, respectively (Table 21). These velocities are probably close to the minimum current velocities necessary to keep the gravel washed and free of silt.

The mean weighted velocity of sites where eggs were collected was 84, 70, and 71 cm/s in 1977, 1978 and 1979, respectively. The range of velocities in which eggs were collected was narrower in 1977 than the other two years (Figure 26). The velocities at sites sampled all 3 years ranged from 0 to 120.7 cm/s while the range of velocities at sites where eggs were collected ranged from 25.5 to 107.9 cm/s.

All eggs, each of three years, were collected over a cobble or pebble substrate. No eggs were collected in substrate covered by or containing sand and silt. Various other workers reported that walleye and sauger select a cobble or pebble substrate (Nelson 1968a, Rawson and Scholl 1978, Priegel 1969, Nelson and Walburg

Table 21. Depth (cm) and velocity (cm/s) criteria for sites where <u>Stizostedion</u> sp. eggs were collected on the Intake gravel bar, 1977-1979.

	Depth		Velocity		
Year	Range	Min 90% CI	Range	Weighted Mean	90% CI for any one egg
1977	30+	46	66-94	84[a,b]	72-96
1978	30+	32	26-108	70[a]	45-94
1979	30+	38	41-102	71[b]	43-95

[a,b] Means with same superscript are significantly different at $p<.001$.

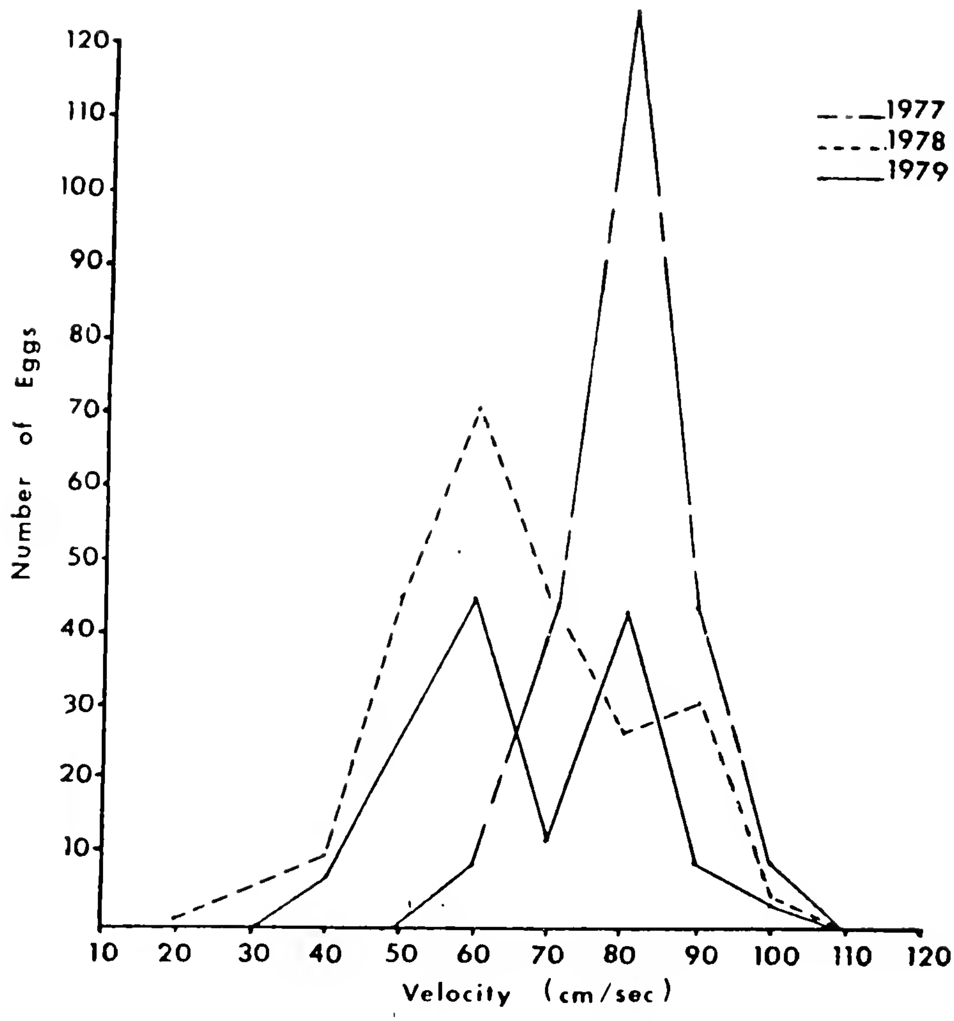

Figure 26. Total number of Stizostedion sp. eggs collected at 10 cm/s water velocity intervalls on the Intake gravel bar during spring 1977, 1978, and 1979.

1977, Johnson 1961) and that egg survival over a silt or sand bottom was poor (Priegel 1970, Johnson 1961).

The percent of eggs collected in water 76 cm or deeper on the Intake gravel bar during 1977, 1978, and 1979 varied inversely with river discharge during peak spawning. This discharge was 7,800, 9,000, and 13,000 cfs for the 3 respective years. Seventy-one, 48, and 30 percent of all eggs sampled during 1977, 1978, and 1979, respectively, were collected at depths of 76 cm or more. During 1977 the minimum velocity where eggs would be expected to occur, 72 cm/s (90% confidence level) was 60% higher than the two subsequent years which had higher flows during April. Apparently more walleye (sauger) were spawning in deeper, swifter sites in 1977, a year of low flow.

Predicted Preferred Spawning Flows

A water surface profile program was used to predict hydraulic parameters at the four Intake egg transects (Graham et al. 1979). These hydraulic parameters were used to predict the amount of top width (almost identical to wetted perimeter) present at various flows which met spawning criteria at each cross-section. The criteria used for 1977 were a mean water velocity between 70 and 96 cm/s, a depth not less than 46 cm, and a cobble or pebble substrate. The criteria used for 1978 and 1979 included: a mean water velocity of 42-96 cm/s, a depth not less than 30 cm, and a cobble or pebble substrate.

Because of wider velocity and depth intervals, the total top width available for Stizostedion sp. spawning was greater for the criteria developed in 1978 and 1979 than 1977 (Figure 27). However, the relative amount of top width available for spawning at various flows was very similar for both curves. At a discharge of less than 140 m^3/s (5,000 cfs) the amount of top width available declined sharply. Optimum flows appeared to be between 170 and 310 m^3/sec (6,000 and 11,000 cfs). Amount of top width suitable for spawning continually declined at flows greater than 310 m^3/s (11,000 cfs). The historical median flow for the Yellowstone during April is 9,170 cfs (from flow duration hydrograph compiled by the U.S. Geological Survey).

Tongue and Powder Rivers

Location, Substrate, and Depth

The substrate of the Tongue and Powder rivers was dominated by fine pebbles often intermixed with particles of coal of similar size. There were also a few runs with boulders and cobble dominating the substrate. Inside bends and slack water areas were composed of sand.

Although the exact location of sauger reproduction in the Tongue and Powder rivers was not pin pointed by the collection of eggs, large numbers of ripe males were regularly collected in runs, and riffle areas less than 1.2 meters in depth. Substrate on these areas was fine pebble. During daylight electrofishing, females were regularly collected in pools, almost all of which were not deeper than 1.2 to 1.5 m. Nelson (1968a) found sauger commonly spawning in water less than 0.6 m and collected eggs 0.6 to 3.7 m below the maximum water surface elevation. Rawson and Scholl

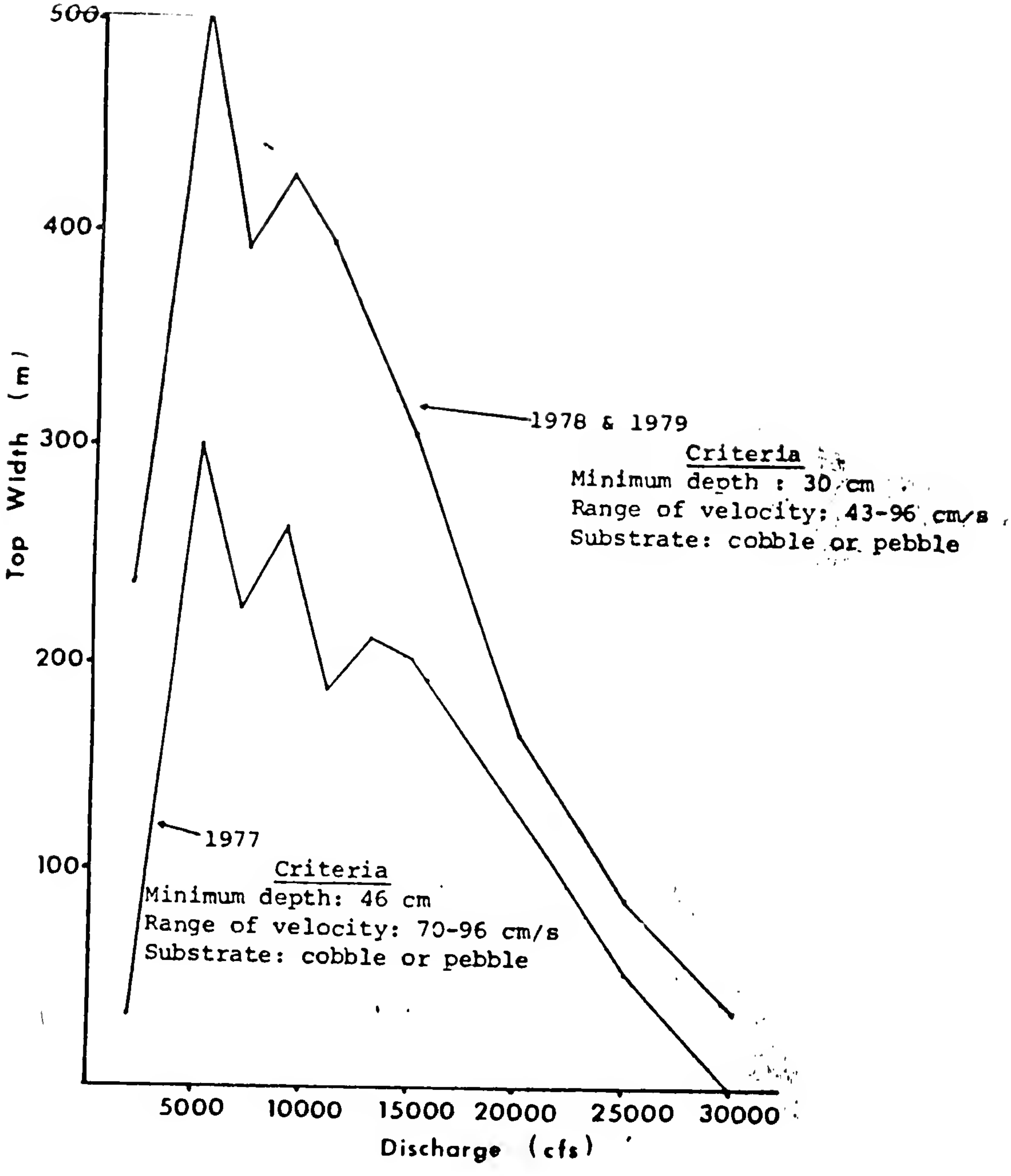

Figure 27. Combined amount of top width of four transects downstream from Intake diversion meeting *Stizostedion* sp. spawning criteria, at various discharges.

(1978) found concentrations of mature sauger along substrate of shale bedrock and sand-gravel in the Sandusky River and in riffles of cobble-boulder in the Maumee River.

To better identify the location of spawning areas for sauger a 32 km reach of the Tongue River from Twelve Mile Dam to the mouth was electrofished on May 9 and 10, 1979. A total of 165 and 37 mature male and female sauger were captured; a catch rate of 5.2 and 1.2 fish per kilometer, respectively. The sex ratio was 4.5 males to one female. Of the 37 females, 26 were gravid, 2 ripe and 9 spent. Males and females were generally caught together with concentrations evident at two locations; 1) near the mouth (river km 0-6) and 2) half-way between the mouth and Twelve Mile Dam (river km 17-22) (Figure 28). Concentrations of sauger were smallest from river km 22 upstream to Twelve Mile Dam (river km 32).

Temperature

The mean water temperatures at which sauger first entered the Tongue River in large numbers was 10 to 12°C. Peak spawning (as indicated by peak numbers of males) occurred at 13.2 to 14.0°C during 1977-1979 (Table 22). During 1980, however, numbers increased when temperatures first exceeded 10°C and then declined after temperatures reached the favorable 13 to 14°C range (Figure A-22).

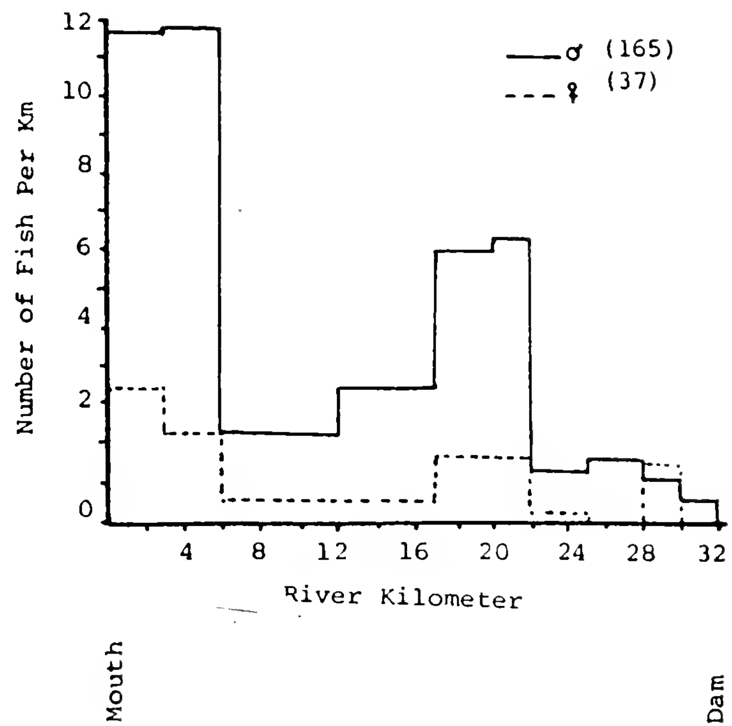

Figure 28. Number of sauger captured per kilometer while electrofishing the Tongue River from 12 Mile Dam (km 32) to the mouth, May 9 and 10, 1979. Total sample size is in parentheses.

Table 22. Water temperatures ($^{\circ}C$) and discharge (ft^3/s) of the Tongue River during the sauger spring migration period, as determined by abundance of mature male sauger.

Migration Spawning Period	1976 April 5-May 5	1977 April 9-April 30+	1978 April 14-May 4	1979 April 19-May 10	1980 March 31-April 29
Date of peak male numbers	May 4	April 15	April 25	April 30	April 14
Mean Water Temperature					
Month of April	10.0	12.5	10.5	9.1	12.2
Day of Peak Numbers	14.0	13.5	13.2	13.5	13.0
Discharge					
Range during Migration Period	370-720	370-720	580-670	451-588	94-404
Mean during Migration Period	451	547	634	507	259
Day of Peak Numbers	700	680	640	445	300
Day of Declining Numbers	700+	-	640	600	300 and 160

Hokanson (1977) listed a range of sauger spawning temperatures from 4 to 14.4°C. Mean water temperature in the Tongue River was generally about 2.5° warmer than the Yellowstone River.

Water temperatures during the time when sauger were collected in the Powder River ranged from 1 to 17°C during 1976-1980 (Table 23). Mean water temperature during April ranged from 7.8 to 10.9°C during 1976 to 1980; an average of 1.6°C colder than mean April temperatures in the Tongue River.

During April, water temperatures usually peaked from noon to 3 p.m. in the Yellowstone and declined to a minimum between midnight and 6 a.m. In the Tongue and Powder rivers, however, the cycle was reversed; water temperatures did not peak until midnight and then declined to minimums between noon and 3 p.m. This makes the difference in water temperature between the tributaries and the mainstem even greater (a mean difference of 5°C warmer in the two tributaries) during the time of day when sauger migration is probably greatest (evening and night).

Streamflows

Sauger spawn when flows are relatively stable in the Tongue River - the period after peak lowland runoff and before mountain runoff. Flows in the Tongue River during 1976-1979 (years when numbers of mature male sauger entering the Tongue River were similar) ranged form 370 to 720 cfs and was generally above 440 cfs (Table 22, Figures A-23, A-24, A-25, and A-26). The discharge

Table 23. Water temperatures (°C) and discharge (ft^3/s) of the Powder River during the sauger spring migration period, as determined by the abundance of mature male sauger.

Migration Period	1976 April 3- May 10	1977 March 24- April 29	1978 March 31- May 1	1979 April 19- May 10[a]	1980 April 8- April 24
Date of peak male numbers	May 4[a]	April 15[a]	April 25[a]	April 30[a]	April 15[a]
Mean water temperature					
Month of April	9.4	9.5	8.5	7.8	10.9
Day of peak numbers	12.0	10.5	9.0	11.0	10.5
Range during migration period	7.0-14.0	10.0-17.0	5.5-11.0	7.5-13.5	3.0-13.0
Discharge					
Range during migration period	436-902	525-1160	436-2640	587-1470	173-299
Mean during migration period	630	753	864	802	262
Day of peak numbers	816	850	516	662	277

[a] Estimated from Tongue River data.

during the spawning run in 1980, however, ranged from 94 to 404 cfs (Figure A-27).

The number of male sauger collected in the Tongue River on a river km basis was lowest in 1980 and highest during 1979 (Figure 4). To make comparisons between years, however, a qualification must be noted. The 220 V electrofishing gear used in 1980 and 1979 was approximately twice as effective in catching sauger as was the 110 V gear used during 1976-1978. This was determined by sampling with both types of gear during 1979. So, if figures for the years 1976-1978 are multiplied by a factor of 2, the maximum number of males collected ranged from 36-48 per km during 1976-1978. This compares nicely to the 38 sauger collected per km during 1979 and isolates 1980 as an odd year when a maximum of 11 males sauger per km were captured, only 25% of that for the previous years.

Spawning success in the Tongue River during 1980, estimated from the maximum drift rate of larval fish, was one third of that of the previous year (Table 24). Unlike other years, in 1980 numbers of male sauger in the Tongue River never reached one distinct peak. Instead, two major declines were evident including one in the middle of the run when the river discharge declined to 300 cfs (Figure A-27). Apparently a flow of 300 cfs is not sufficient in the tongue River to stimulate continued sauger presence or movement into this tributary. The second peak in male sauger numbers in 1980 may be from a movement of sauger out of

Table 24. Number of larval sauger collected and estimated rate of drift in the Tongue River near its mouth, 1979 and 1980.

Date	Volume of water sampled (ft^3)	Number larvae collected	Discharge of Tongue River (ft^3/s)	Estimated number of larvae passing into Yellowstone per minute
		1979		
April 30	37125	0	451	0
May 1	16560	1	459	1.7
May 5	37125	17	471	12.9
May 7	20925	1	570	0.5
May 10	16848	8	583	16.6
May 14	34875	13	526	11.8
May 16	20880	1	521	1.5
May 21	50922	1	467	0.6
May 23	45101	42	447	25.0
May 31	25067	0	777	0
		1980		
April 21	3621	3	151	7.5
April 22	4466	0	153	0
April 24	7938	2	189	2.9
April 25	18940	2	98	0.6
April 28	19092	0	94	0
April 29	10710	0	134	0
May 2	34182	0	200	0
May 5	10634	0	200	0
May 7	10716	3	184	1.8
May 12	4216	0	156	0

upstream areas in the lower Tongue River as flows continued to declines all the way down to 94 cfs.

Obviously the minimum flow necessary to provide for sustained sauger reproduction is greater than 300 cfs, perhaps 400 cfs or greater. Elser and McFarland (1977) recommended a discharge of 525 cfs (40 percentile flow) which may be close to the optimum flow. Mean April discharge from 1976 to 1979 ranged from 419 to 648 cfs.

The flow regime in the Powder River is similar to the Tongue River in which sauger spawn during a period of generally moderate, stable flows (Figure A-28, A-29, A-30, A-31, and A-32). Mean April flows ranged from 583 to 1073 cfs during 1976 to 1979 (Table 23). The mean April discharge during 1980, 270 cfs, was only lower once from 1938 to 1980. This occurred in 1961 when the mean April discharge was 109 cfs. Although sauger reproduction was documented in the Powder River during 1980, it is not known how low flows affected total larval sauger production as no previous collections are available for comparison.

Larval sauger were collected in the Powder River from May 2 to 12, 1980 (Table 25); a range of 17 to 27 days after the maximum number of sauger were captured. Continued work is necessary to quantify critical low flows and optimum flows for sauger reproduction in the Powder River.

Table 25. Number of larval sauger collected and estimated rate of drift in the Powder River near its mouth, 1979 and 1980.

Date	Volume of water sampled (ft^3)	Number larvae collected	Discharge of Powder River (ft^3/s)	Estimated number of larvae passing into Yellowstone per minute
			1979	
May 15	75454	0	726	0
May 18	93146	0	726	0
May 23	120871	0	769	0
			1980	
April 22	4330	0	216	0
April 30	35511	0	245	0
May 2	22283	3	240	1.9
May 5	18458	1	206	0.7
May 8	14166	3	171	2.2
May 12	13672	6	145	3.8
May 20	17724	0	454	0
May 21	2773	0	368	0

Other Yellowstone River Sites

Walleye were found spawning at 14 sites in the mainstem of the Yellowstone in addition to the area downstream from Intake diversion dam in 1980. Most of these sites, all small compared to the Intake spawning area, were located adjacent to gravel islands or along gravel shores at the head or mouth of dry side channels. The physical criteria (depth, substrate, and velocity) at these sites were very similar to that at the Intake gravel bar and probably played a role in the selection of these sites by walleye. The velocities where eggs were collected ranged from 76 to 134 cm/s with a mean of 95.2 cm/s (Table 18). Depths ranged from 61 to 91 cm and substrate was usually cobble or pebble with one site being fine pebbles. Sites where spawning occurred were runs along the source or mouth of dry side channels or along small gravel islands (Figure 24).

Flows which would result in favorable spawning habitat on the Intake gravel bar should also result in favorable spawning conditions at these other spawning areas. Flows in 1980, when these sites were discovered, were within the range determined favorable for Intake.

To maintain the integrity of the unique mainstem spawning areas, channel maintenance flows are required during the high water period. Islands and side channels are formed and maintained as a result of a period of highwater or "flood flow" (Leopold et al. 1964, Martin 1977). Peterman (1979) suggested that this flood flow is 52,000 cfs ad should occur at a frequency of twice every 3 years. Necessary duration of this flow is not known but is suggested to be for a minimum of 24 hours (Peterman 1979).

SUMMARY

Chronology of abundance of sauger, tag returns and distribution of eggs and larvae show that the Tongue and Powder rivers are two major spawning areas for this species in the Yellowstone River system. Sauger larvae were captured in drift nets in the Tongue and Powder rivers near their mouth, demonstrating that successful reproduction is occurring in these two tributaries. No larval sauger were caught in the Yellowstone upstream from the Tongue River. Mature sauger were not abundant in the mainstem between Forsyth (river km 381) and the North Dakota border (river km 26) at a time when spawning concentrations were evident in the Tongue and Powder rivers. Only downstream from Intake diversion, river km 114, was sauger reproduction documented in the mainstem of the Yellowstone River. However, this was also a major walleye spawning area; sauger eggs comprised only 2 to 12 percent, depending on the year, of the combined walleye-sauger eggs collected from this area. Loss of the Tongue and Powder rivers as sauger spawning areas could eventually decrease sauger abundance in the Yellowstone River if alternative spawning areas were not utilized.

Walleye are not numerous in the Yellowstone River except during April and May when large numbers migrate out of Garrison Reservoir (an impoundment on the Missouri River) and move upstream into the Yellowstone River. A spawning area, which supported large numbers of mature walleye and small numbers of mature sauger, was discovered in 1976 just downstream from Intake diversion (river km 114). In April of 1978, the number of mature walleye on the Intake gravel bar was estimated to be 991 fish per kilometer. In 1980 numbers were thought to be ever higher. Of the 2488 mature walleye and sauger collected form the Intake gravel bar from 1976 to 1980 24% were sauger, indicating that primarily walleye were using this area for spawning. Migrant walleye are apparently becoming more numerous in the Yellowstone River and are expanding their spawning range. Intake was the only area where significant walleye reproduction was documented in 1977 while 14 other spawning sites were located in 1980 including 2 upstream near Glendive (river km 163). Successful walleye reproduction in the Yellowstone River is probably very important to walleye recruitment in the upper reaches of Garrison Reservoir where suitable spawning areas may be limited or lacking.

Sauger and walleye eggs hatch during the end of April or beginning of May when water levels are beginning to increase from mountain runoff. The distribution of larvae and young-of-the-year sauger indicates that many sauger hatched in the Tongue and Powder rivers drift to areas near the mouth of the Yellowstone River or into the Missouri River. No young-of-the-year walleye were collected in the Yellowstone River suggesting that walleye larvae drift into Garrison Reservoir.

Young sauger appear to move upstream beginning at age 0+ and continue during their second year of life. Tag returns and age structure from electrofishing samples revealed that although this upstream migration began the first year for some sauger, for most one or more years passed before substantial upstream movement occurred. Large concentrations of juvenile sauger were noted from Glendive (river km 145) downstream.

Flows in Tongue River during the time of sauger migration and spawning ranged from 370 to 720 cfs during 1976-1979 and were generally above 440. Numbers of sauger entering the Tongue River each of these four years was very similar. Flows during 1980 were much lower, ranging from 94 to 404 cfs during the spawning run. Numbers of sauger entering the Tongue River in 1980 were significantly smaller than each of the previous four years. Maximum numbers of larval sauger drifting in the Tongue River in 1980 was estimated to be one third of that the previous year. A critical low flow, 300 cfs appeared to cause sauger emigration during the middle of the spawning period. This critical flow is 4 times the instantaneous discharge allocated for instream purposes, 75 cfs. This flow is much too low to maintain the Tongue River as an important sauger spawning area.

Optimum flows were predicted for the Intake spawning area (primarily walleye) using observed depth, velocity, and substrate criteria at egg sampling sites. Predicted acceptable spawning flows ranged from 6000 to 11,000 cfs. In 1977 and 1978 discharge during time of spawning was usually within this range. Numbers of

Stizostedion sp. eggs were similar these two years. In 1979, flows were as high as 16,800 cfs during the spawning period and water temperatures were 3.5 to 4.0°C lower than 1977 and 1978. Maximum egg abundance and number of mature walleye were sharply lower this year. Allocated instream flows during April for the mainstem at Sidney (rive km 56) is 6,808 cfs and should be adequate for mainstem walleye and sauger reproduction.

Fourteen walleye spawning sites, in addition to the one at Intake, were located during 1980. The upstream and downstream most sites were at river kilometer 163 (upstream from Glendive) and 26 (Montana-North Dakota border). Few spawning sites were located downstream from Sidney (river km 56) because of the paucity of suitable substrate and lack of adequate velocities. Most spawning sites were runs along the head or mouth of dry side channels or along gravel islands. None of the sites, the largest being several hundred meters long, were nearly as extensive as the Intake spawning area. Spawning flows determined to be adequate for the Intake spawning area would also probably be sufficient for these other areas. To maintain the unique physical characteristics at these sites a periodic bankful flow of 52,000 cfs is necessary in 2 of 3 years.

Intake diversion does not block upstream migration of sauger or walleye but does tend to concentrate these two species particularly during spring and fall. At allocated discharges of 2670 and 3276 cfs during September and October migration over this structure, particularly by young fish, may be greatly reduced or eliminated. Forsyth diversion may inhibit sauger from proceeding further upstream. Tag returns and size structure of the population upstream from Forsyth diversion indicate that mostly larger individuals negotiated this structure.

Estimates of the sauger populations for an 8 km reach of the Yellowstone River at Miles City (river km 298) during fall of 1978, 1979, and 1980 was 1981, 1416, and 1809 fish, respectively. These estimates as well as other related population statistics can be used to monitor any changes in the sauger population.

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APPENDIX

Table A1. Sex ratio (males:females) of mature sauger collected in the Yellowstone River downstream from Intake diversion, April-May, 1976-1980.

Year	Sample Size	Range of Sex Ratios	Sex ratio for all fish collected	Sex ratio when first ripe or spent female caught
1980	128	0.3:1-3.7:1	1.5:1	1.3:1
1979	37	0.8:1-8.0:1	6.4:1	0.8:1
1978	106	0.3:1-10.0:1	3.5:1	0.3:1
1977	201	2.3:1-17.5:1	9.1:1	2.3:1
1976	134	0.2:1-3.7:1	1.6:1	0.2:1

Table 2A. Sex ratio (males:females) of mature sauger collected in the Tongue River, March-May, 1976-1980.

Year	Sample size	Range of sex ratios	Sex ratio for all fish collected	Sex ratio when first ripe or spent female caught	Date of capture of first ripe or spent female in: Tongue River	Yellowstone River
1980	246	2:1-13:1	3.2:1	2.5:1	April 29	April 17
1979	580	4:1-61:1	9.3:1	4.2:1	May 10	April 25
1978	360	3:1-35:1	7.6:1	5.3:1	April 24	April 24
1977	533	3:5:1-33:1	8.2:1	3.5:1	April 26	April 23
1976	918	5:1-89:1	22.3:1			April 22

Table A3. Sex ratio (males:females) of mature cauger collected in the Powder River, March-May, 1976-1980.

Year	Sample size	Range of sex ratios	Sex ratio for all fish collected	Sex ratio when first ripe or spent female caught in: Powder River	Yellowstone River
1980	25		24:1	-	12:1 (April 17)
1979	29		13.5:1	-	-
1978	48	0.5:1-6:1	2.7:1	1:2 (April 27)	1:1 (April 24)
1977	302	0.3:1-34:1	9.8:1	2:1 (April 15)	9.1 (April 23)
1976	169	2:1-33:1	12:1	3.1 (May 3)	16.1 (April 22)

Table A4. Sex ratio (males:females) of mature walleye collected in the Yellowstone River downstream from Intake diversion, April-May, 1976-1980.

Year	Sample size	Range	Sex ratio for all fish collected	Sex ratio when first ripe or spent female caught
1980	324	3:1-17:1	11:1	10:1
1979	139	3:1-39:1	12:1	3:1
1978	888	6:1-73:1	16:1	11:1
1977	199	5:1-48:1	12:1	12:1
1976	352	2:1-40:1	9:1	2:1

Table A5. Age composition and mean length ($\bar{L}$) of sauger collected from the Tongue and Yellowstone rivers, spring 1979.

	Tongue River			Yellowstone River at Intake		
Age	n	%	$\bar{L}$	n	%	$\bar{L}$
1	0	0	-	0	0	-
2	21	3	283	18	12	268
3	97	16	230	76	51	307
4	175	28	361	29	20	345
5	166	27	401	22	15	412
6	108	17	431	3	2	412
7	50	8	451	0	0	-
8	10	2	457	0	0	-
Total	627			148		
Grand Mean			383			330
Standard Deviation			60.4			59.3
95% Confidence Interval			378-388			320-340

Table A6. Mean lengths($\bar{L}$), weights($\bar{W}$) and grand means weighted according to percent in population, of sauger in the Yellowstone River at Miles City, Fall, 1978 and 1979.

	1978			1979		
Age	n	$\bar{L}$ (mm)	$\bar{W}$(g)	n	$\bar{L}$(mm)	$\bar{W}$(g)
1+	67	277	197	52	277	187
2+	141	322	264	135	310	238
3+	146	355	360	126	346	338
4+	75	387	473	93	378	445
5+	27	431	690	34	412	560
6+	10	454	827	7	476	951
7+	3	588	1467	2	557	1635
8+	0	-	-	1	483	948
Grand Mean		338.7	328.2		344.36	328.9

Table A7. Mean length ($\bar{L}$) of each year class and grand mean length for all sauger collected in the entire Yellowstone River, Autumn, 1977-1979.

	1977		1978		1979		1980	
Age	n	$\bar{L}$	n	$\bar{L}$	n	$\bar{L}$	n	$\bar{L}$
0+	3	-	62	188	74	175	139	181
1+	140	251	233	259	191	263	564	258
2+	176	305	291	305	402	306	869	305
3+	305	344	291	357	298	346	894	349
4+	112	387	192	402	214	392	518	395
5+	66	452	80	447	114	434	260	443
6+	20	498	36	493	53	482	109	489
7+	8	567	7	555	5	549	20	558
8+	-	-	2	-	5	498	7	498
Total	960		1204		1441		3605	
Grand Mean[a]		341		340		336		339

[a]Includes some sauger that were not aged.

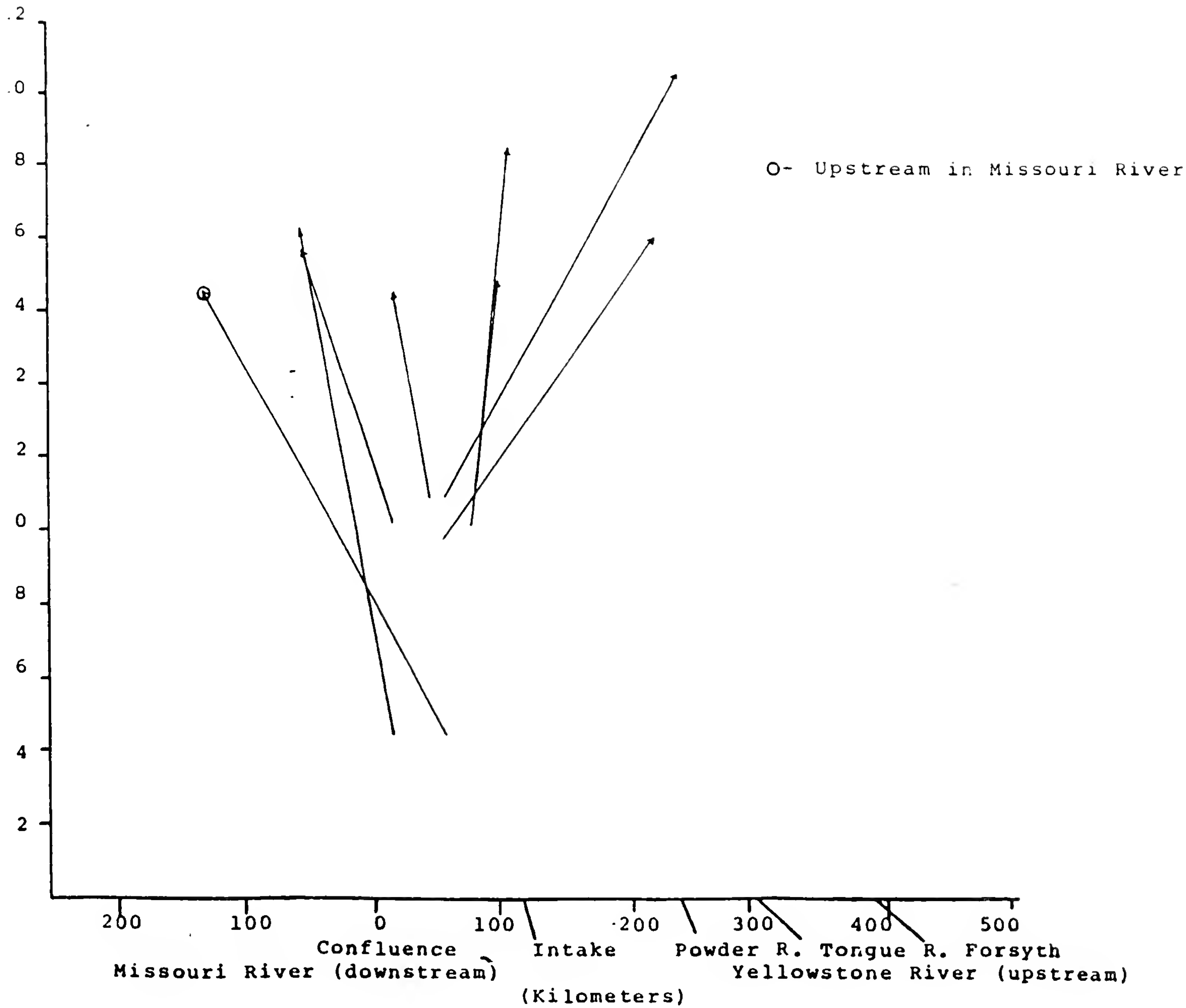

Figure A1 Movement of sauger tagged in the Yellowstone River from river kilometer 56 to 106 (Sidney to 8 km downstream from Intake diversion) during 1974 through 1979 and recaptured in a subsequent year.

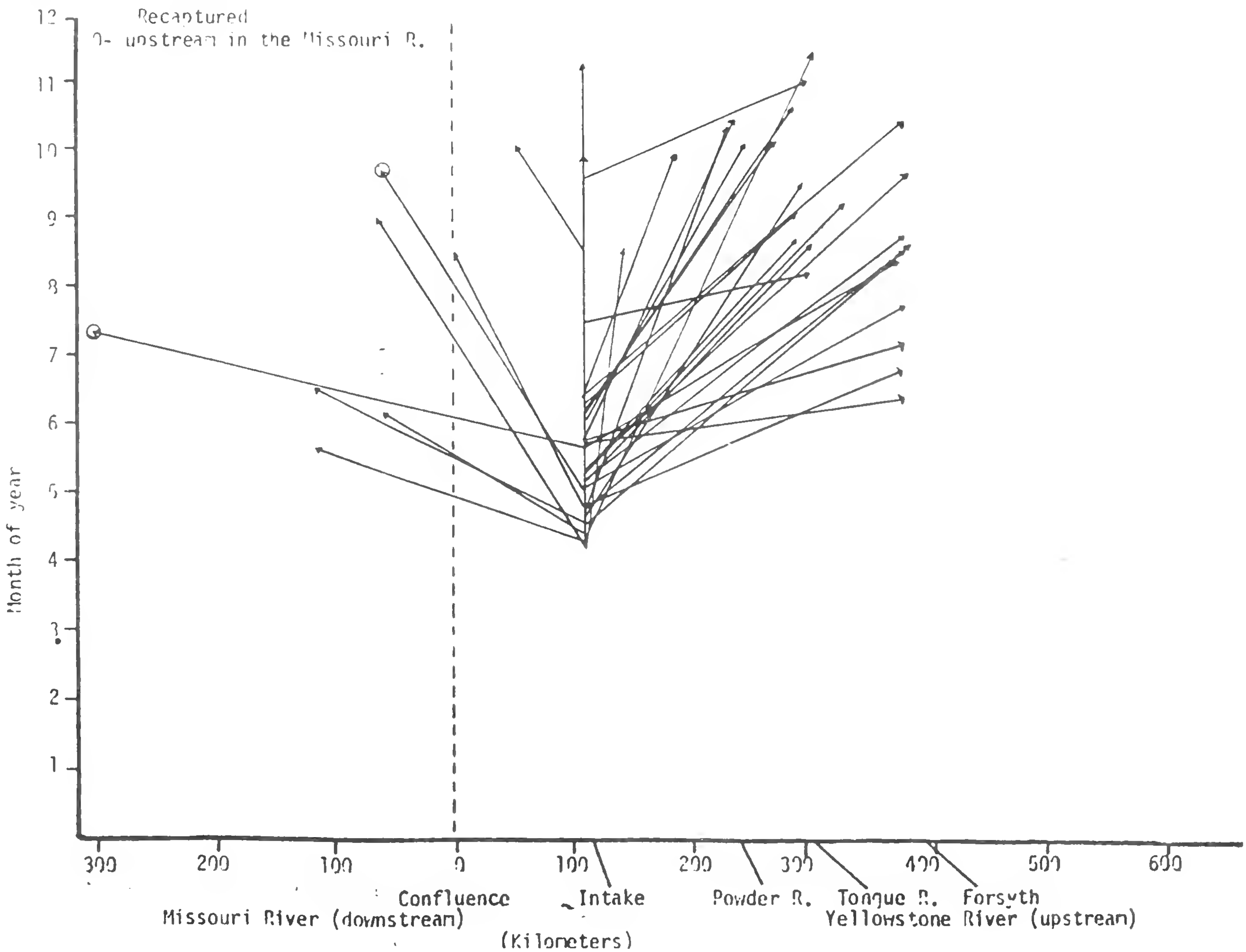

Figure A2. Movement of sauger tagged in the Yellowstone River downstream from Intake diversion from 1975-1980 and recaptured in the Yellowstone or Missouri rivers during the same calendar year.

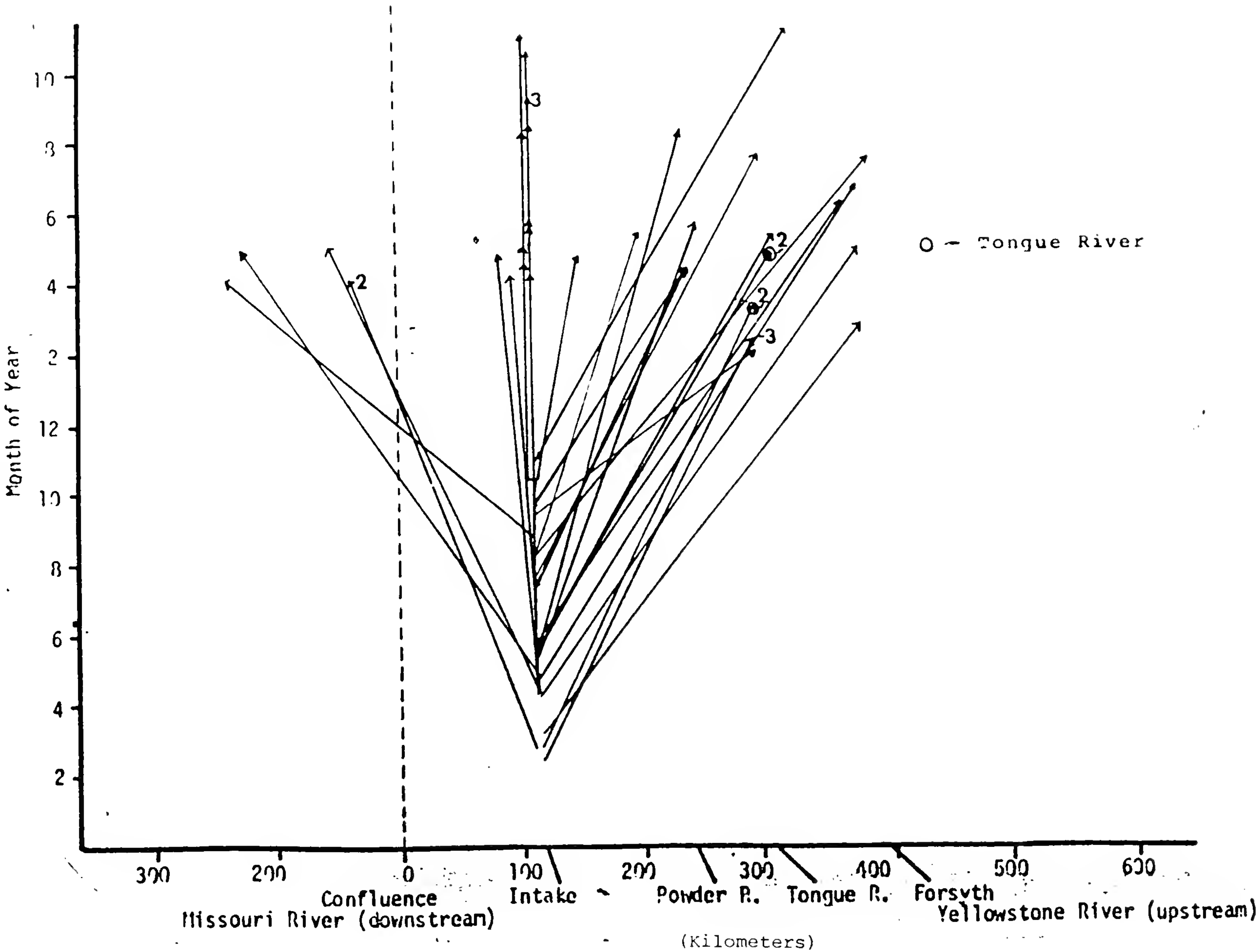

Figure A3. Movement of sauger tagged downstream from Intake Diversion from 1974-1979 and recaptured in subsequent years.

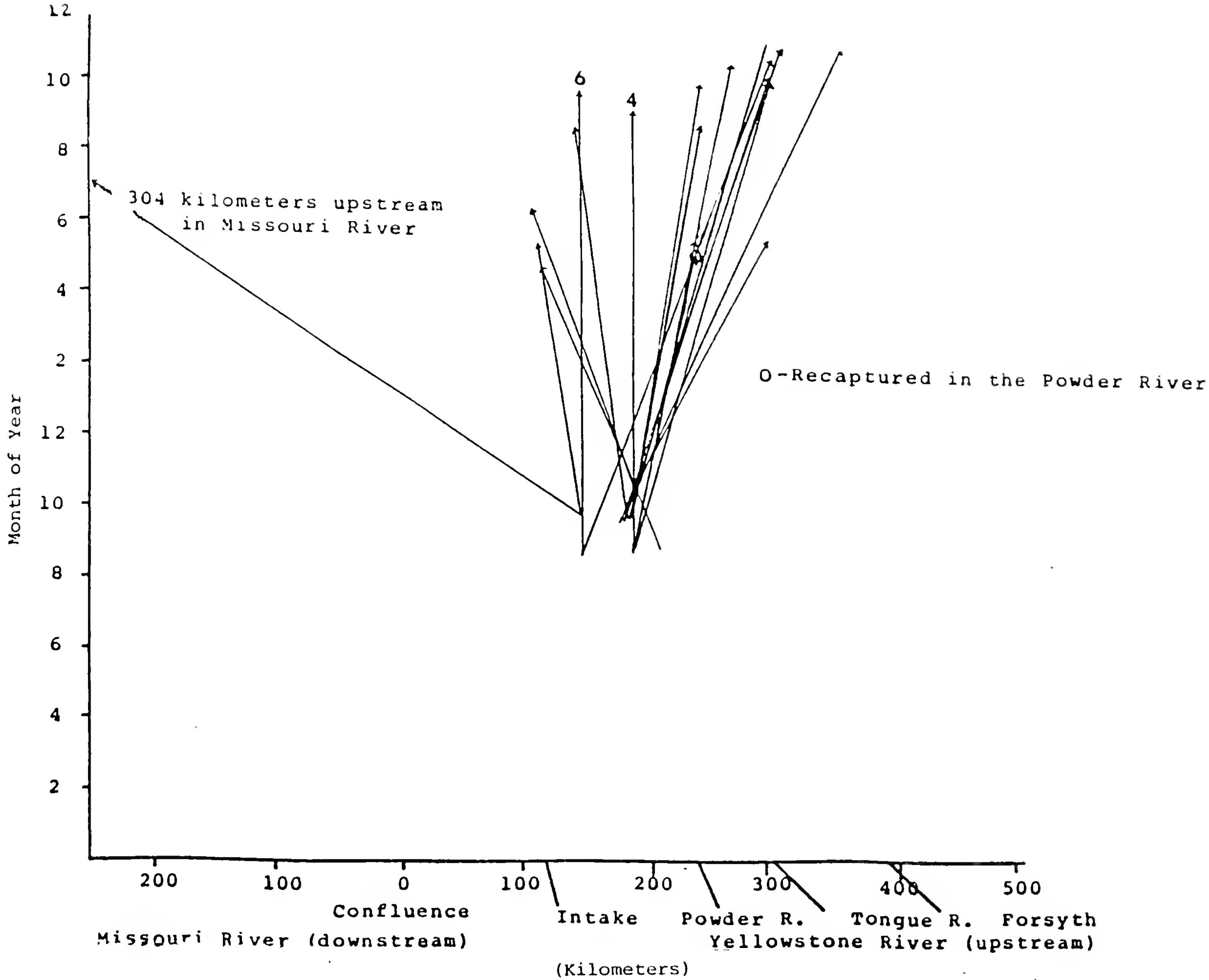

Figure A4. Movement of sauger tagged in the Yellowstone River from river kilometer 71 to 142 (upstream from Intake diversion to 8 km downstream from the mouth of Powder River), 1974-1979 and recaptured in a subsequent year.

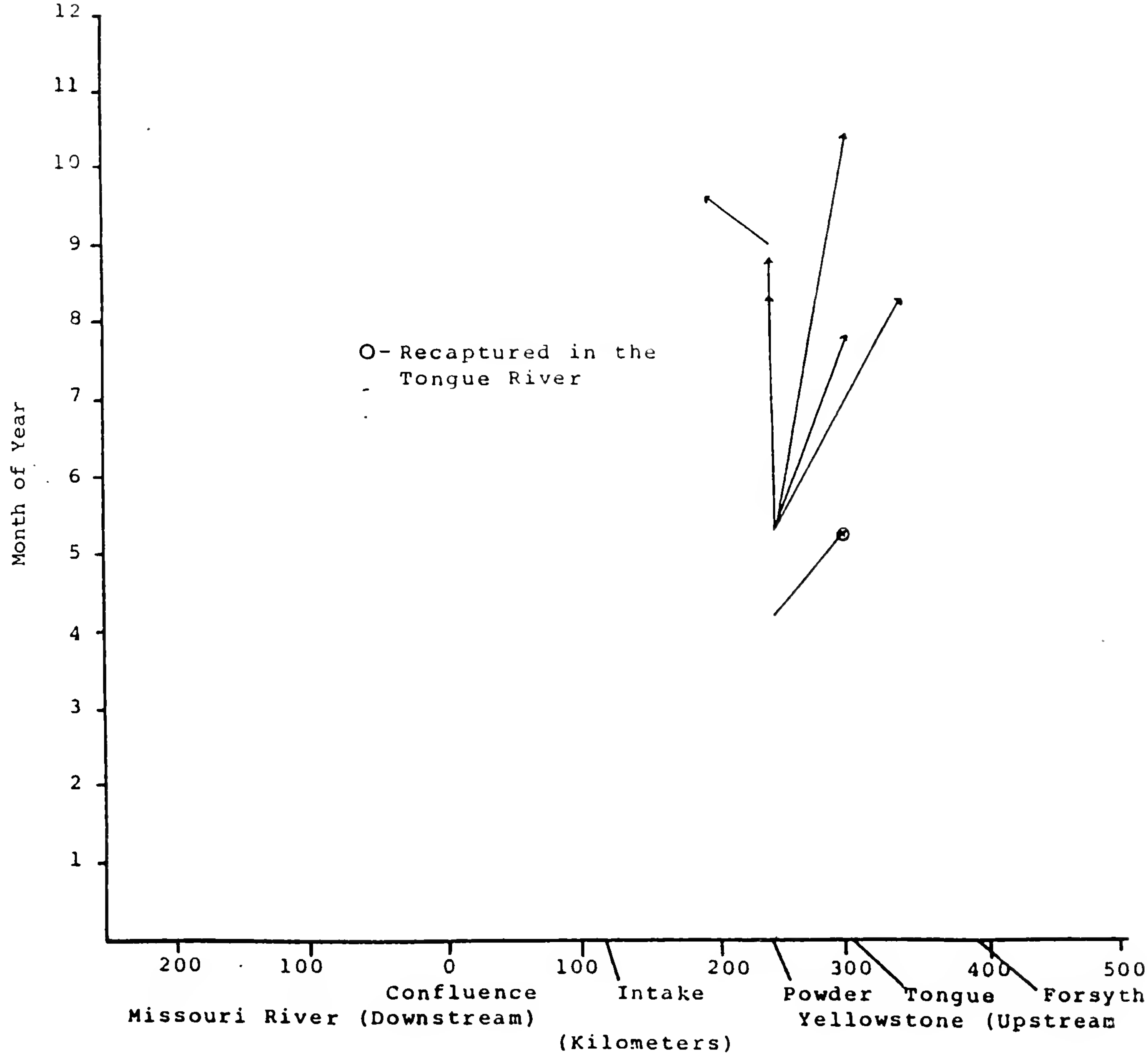

Figure A5 Movement of sauger tagged in the Yellowstone River near the mouth of the Powder River, 1974-1980, and recaptured in the same calendar year.

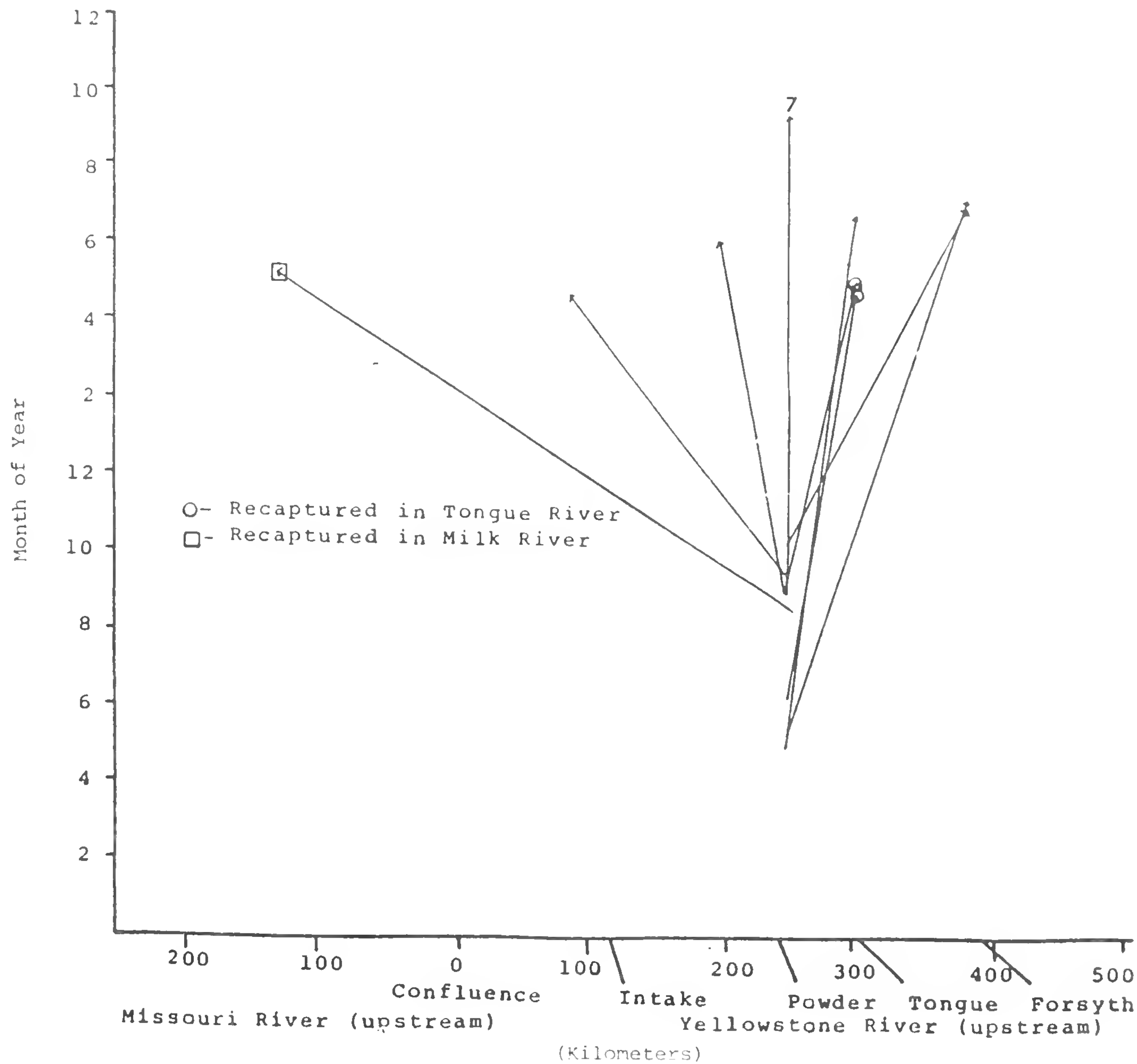

Figure A4. Movement of sauger tagged during 1974-1979 in the Yellowstone River near the mouth of the Powder River and recaptured in a subsequent year.

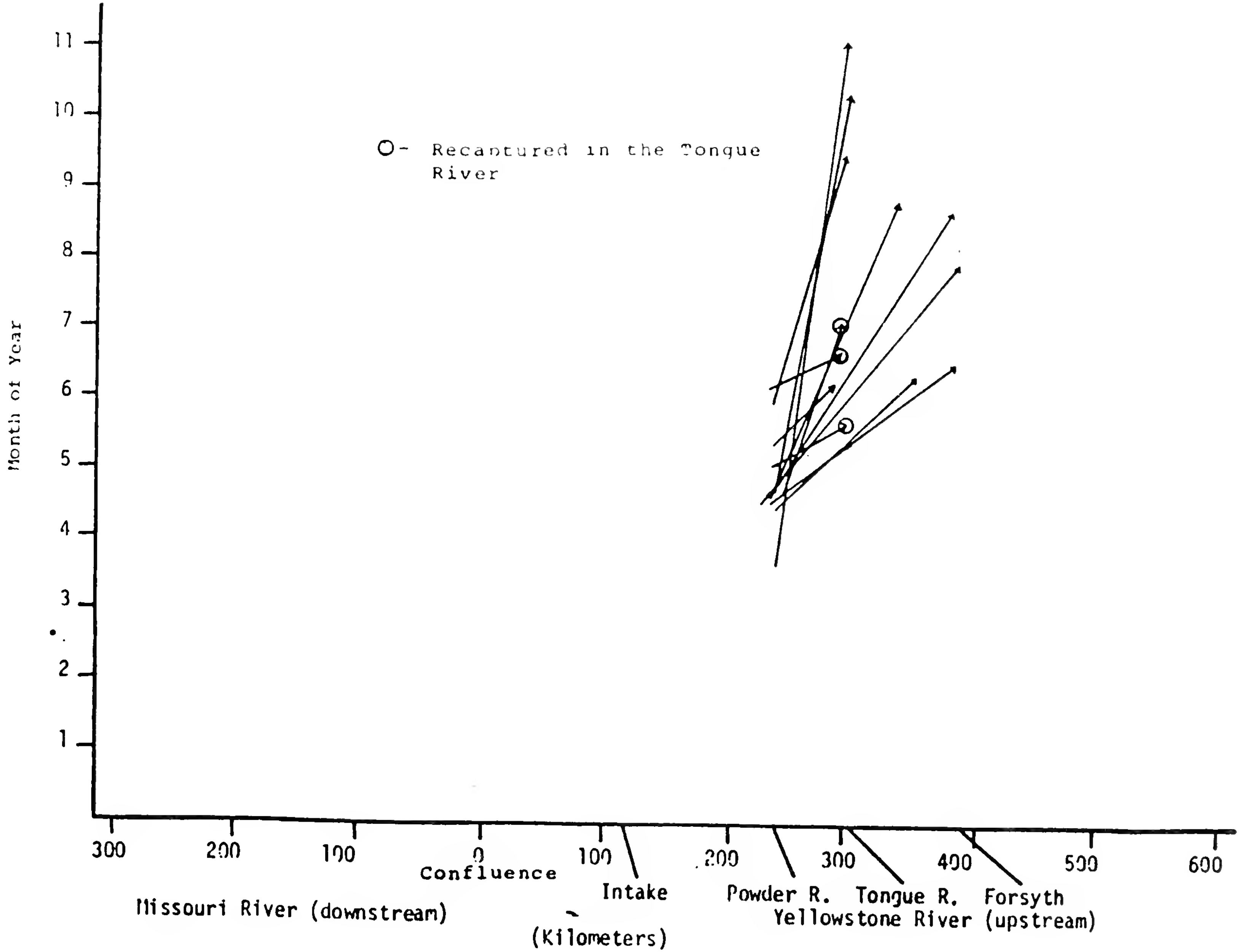

Figure A7. Movement of sauger tagged in the Powder River in 1976-1979 and recaptured during following calander years.

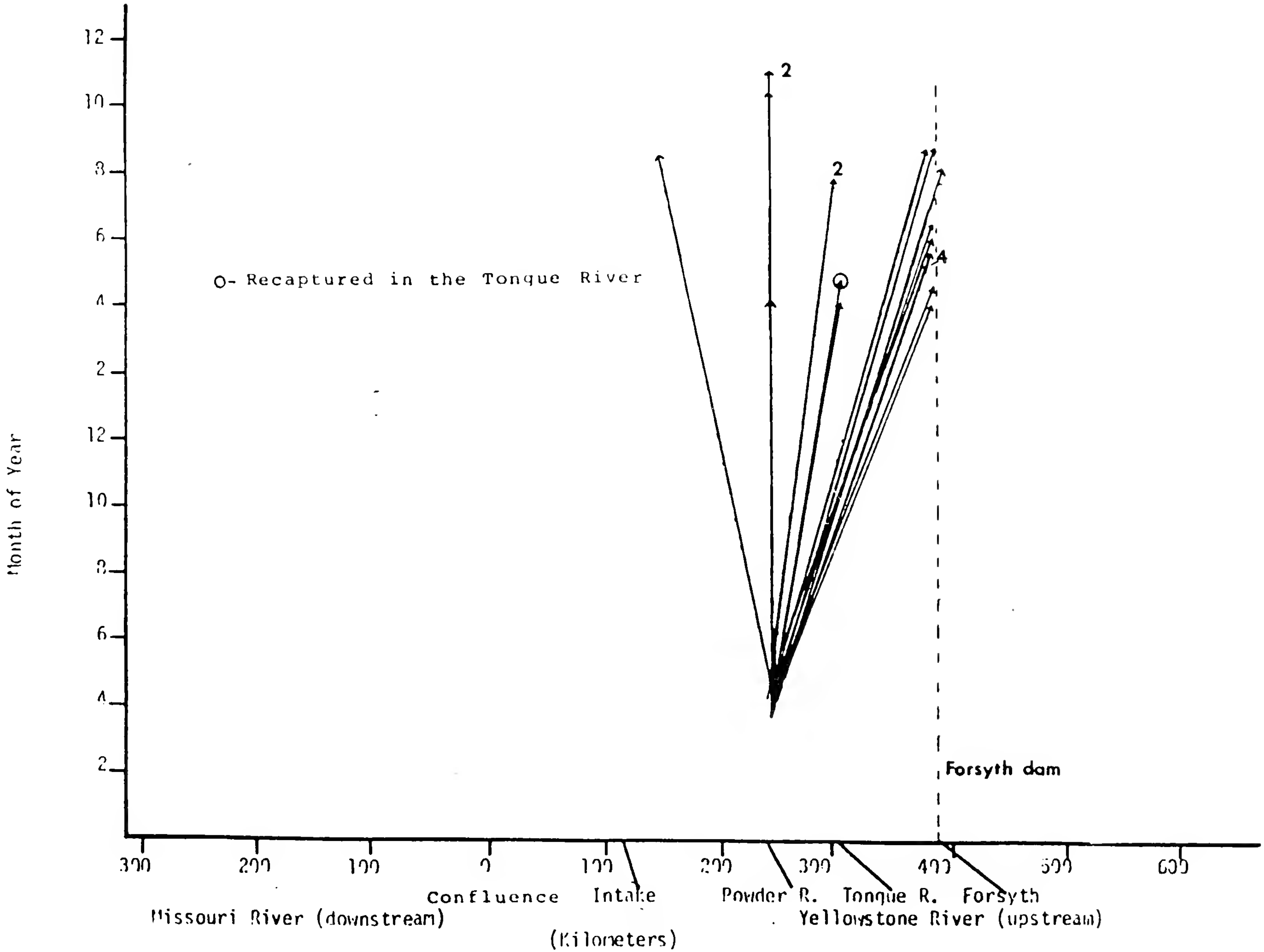

Figure A8. Movement of sauger tagged in the Powder River in

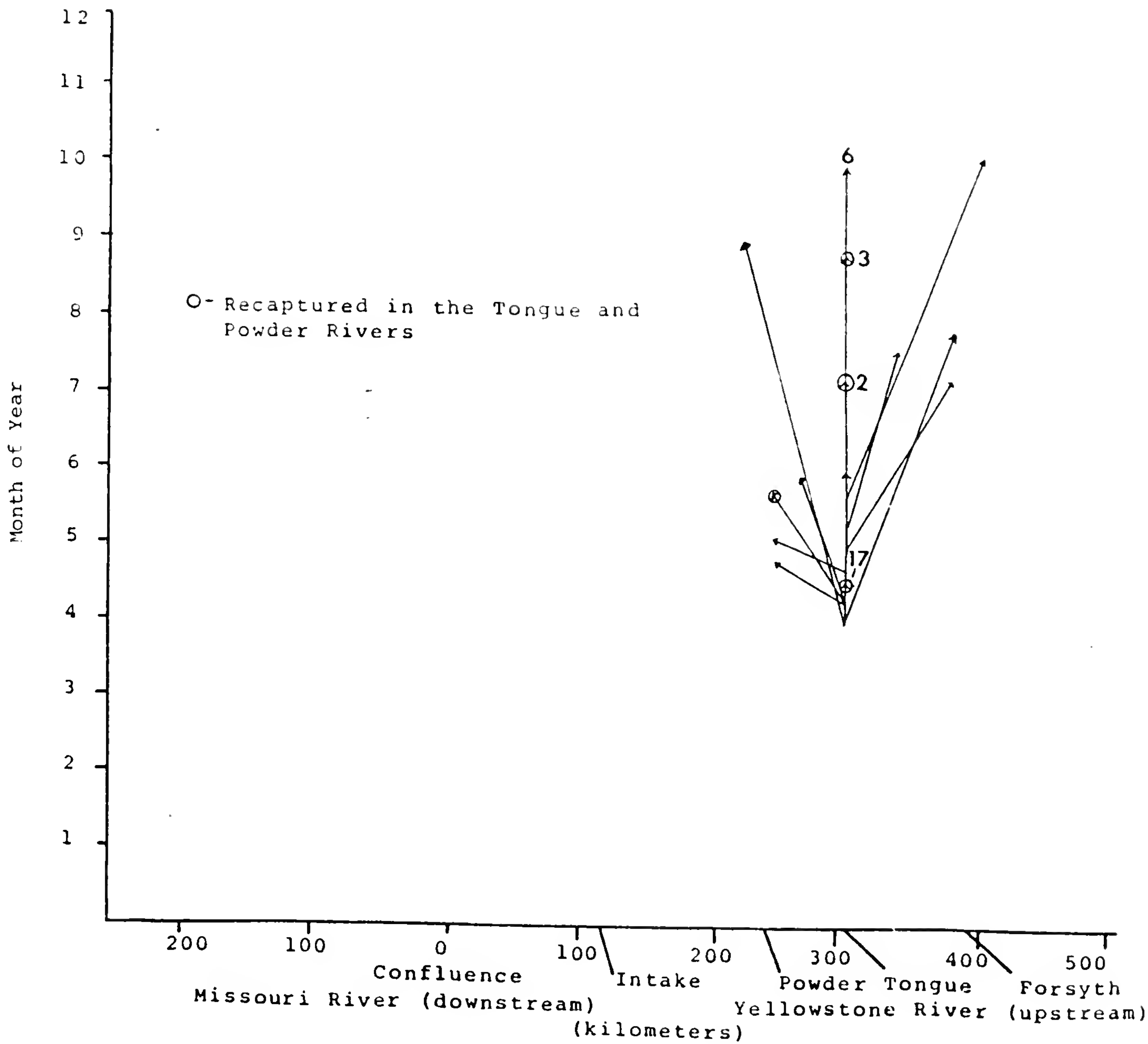

Figure A9 Movement of sauger tagged in the Yellowstone River near Miles City and recaptured during the same calendar year, 1974-1980.

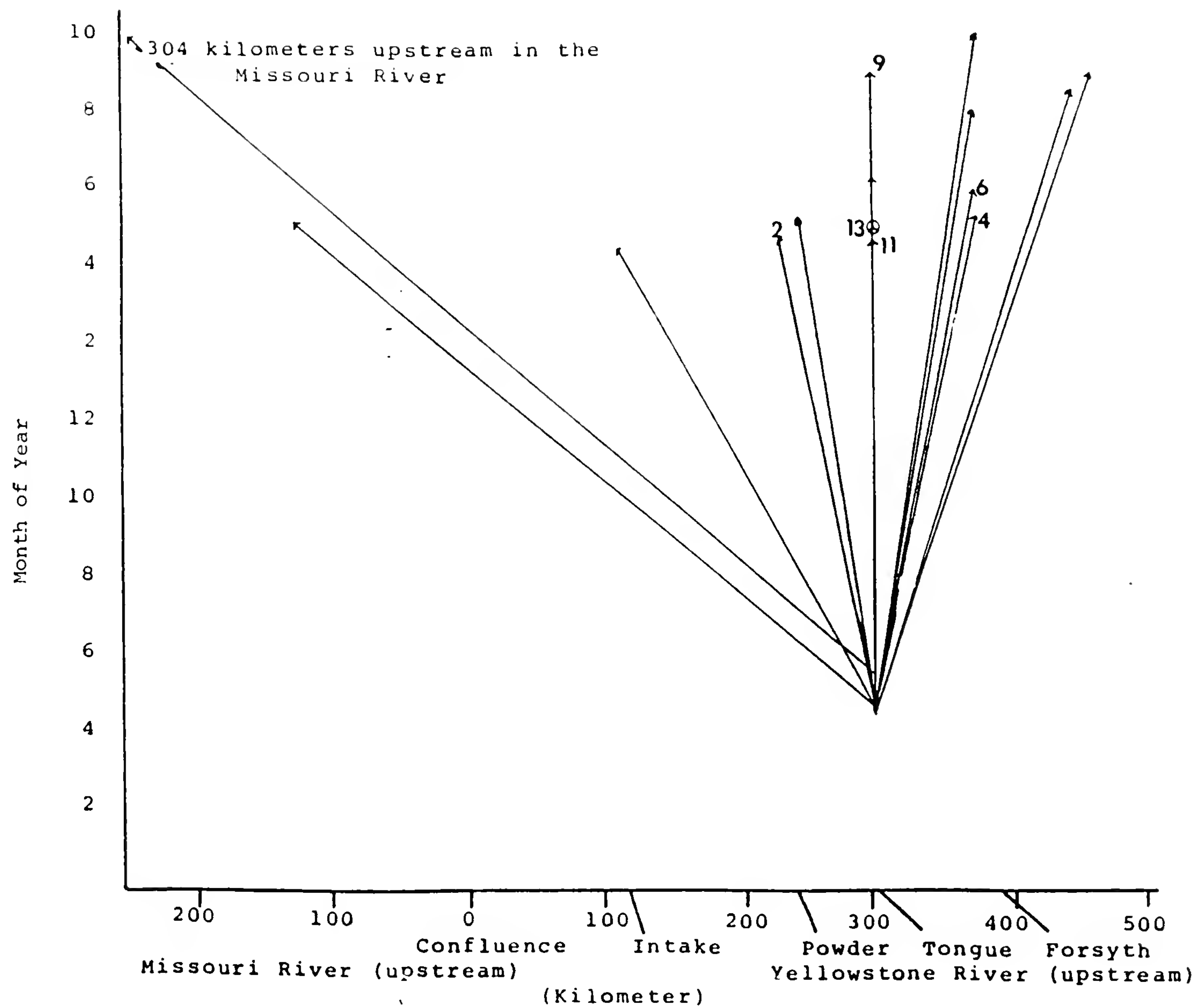

Figure A10. Movement of sauger tagged during spring of 1974-1979 in the Yellowstone River near Miles City and recaptured in subsequent years.

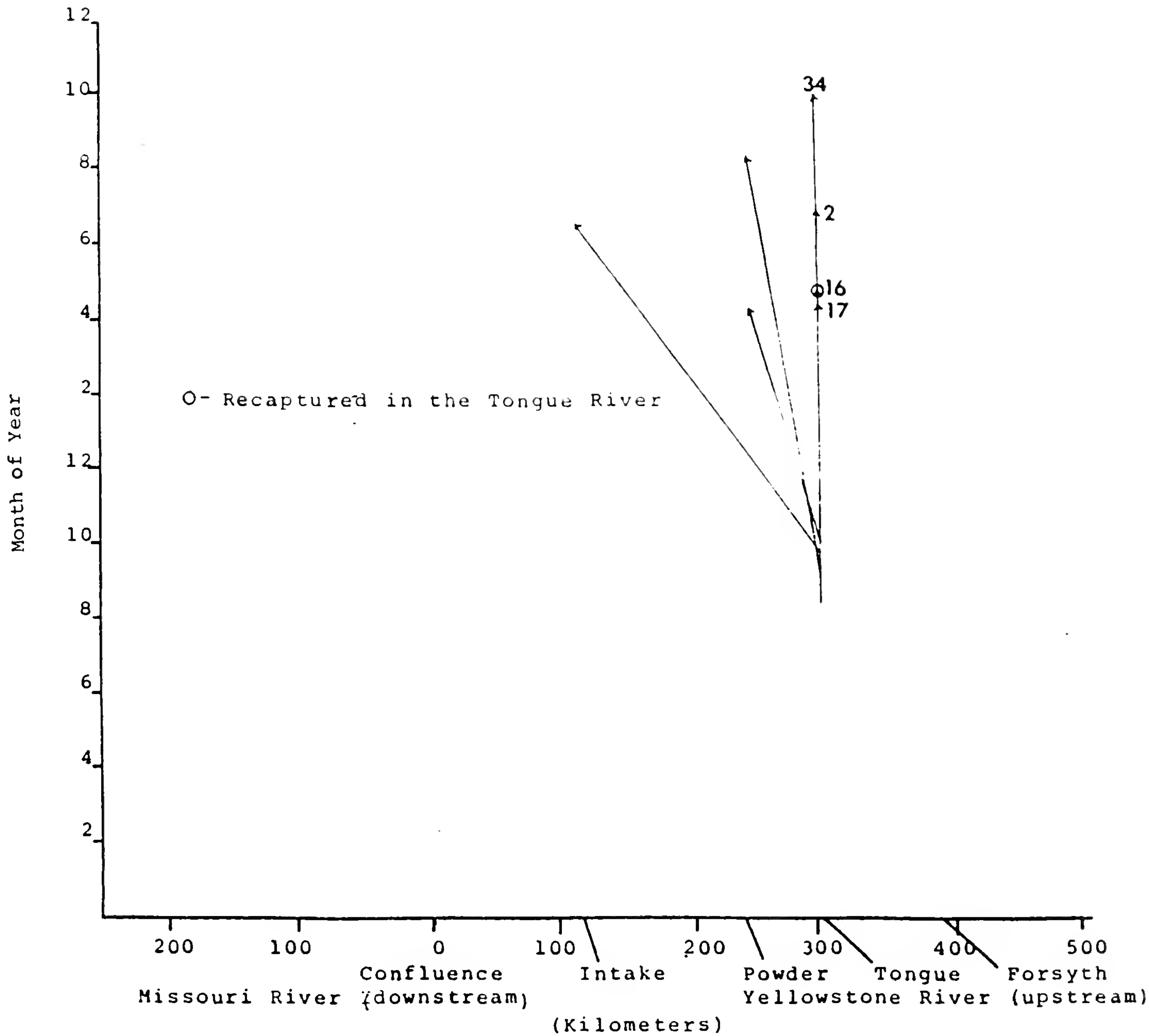

Figure Aii. Movement of sauger tagged in the Yellowstone River near Miles City, summer through fall, 1974-79, and recaptured in subsequent years.

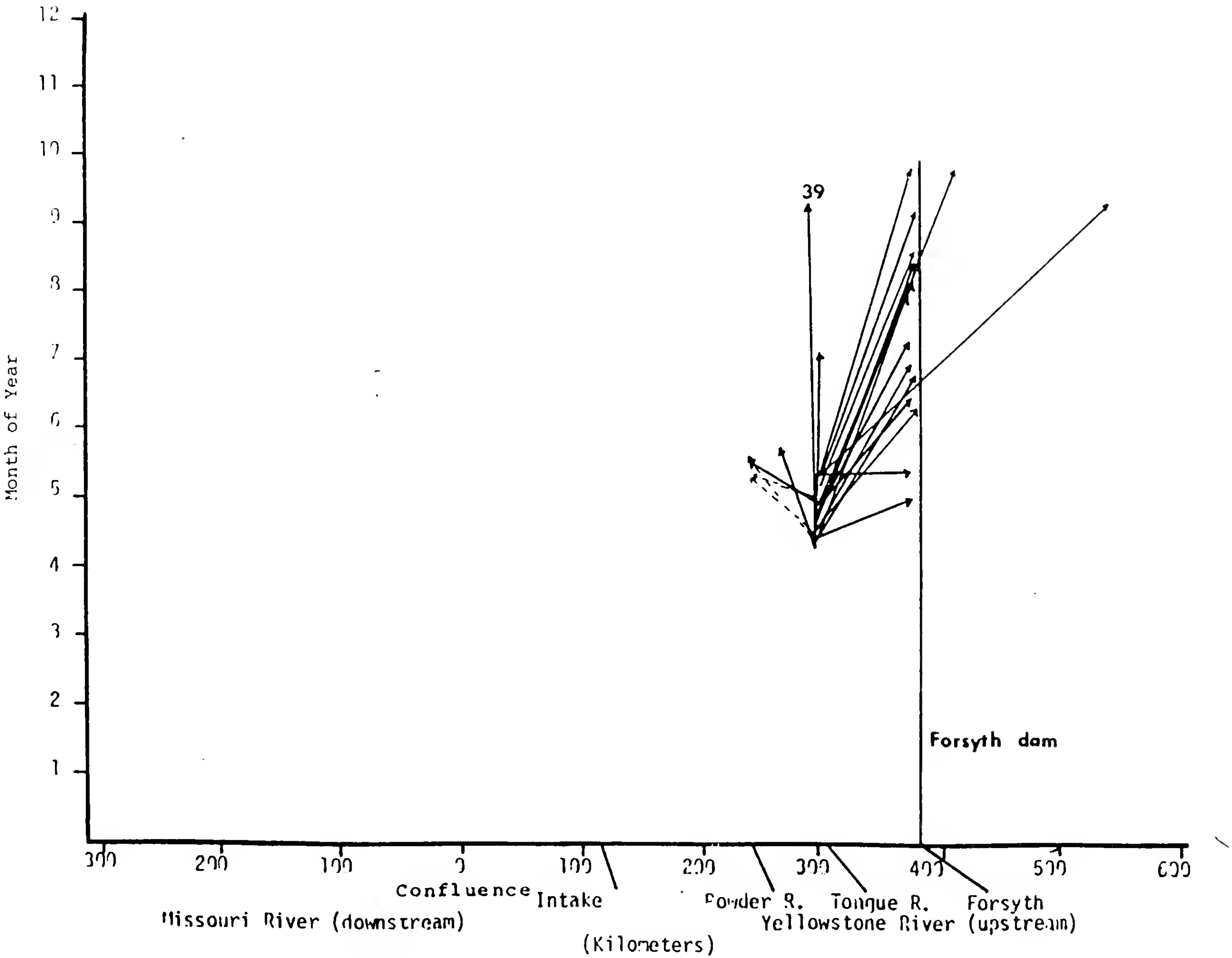

Figure A12. Movement of sauger tagged in the lower Tongue River, 1975-1980, and recaptured in the Yellowstone (-) or Powder (---) rivers during the same calendar year.

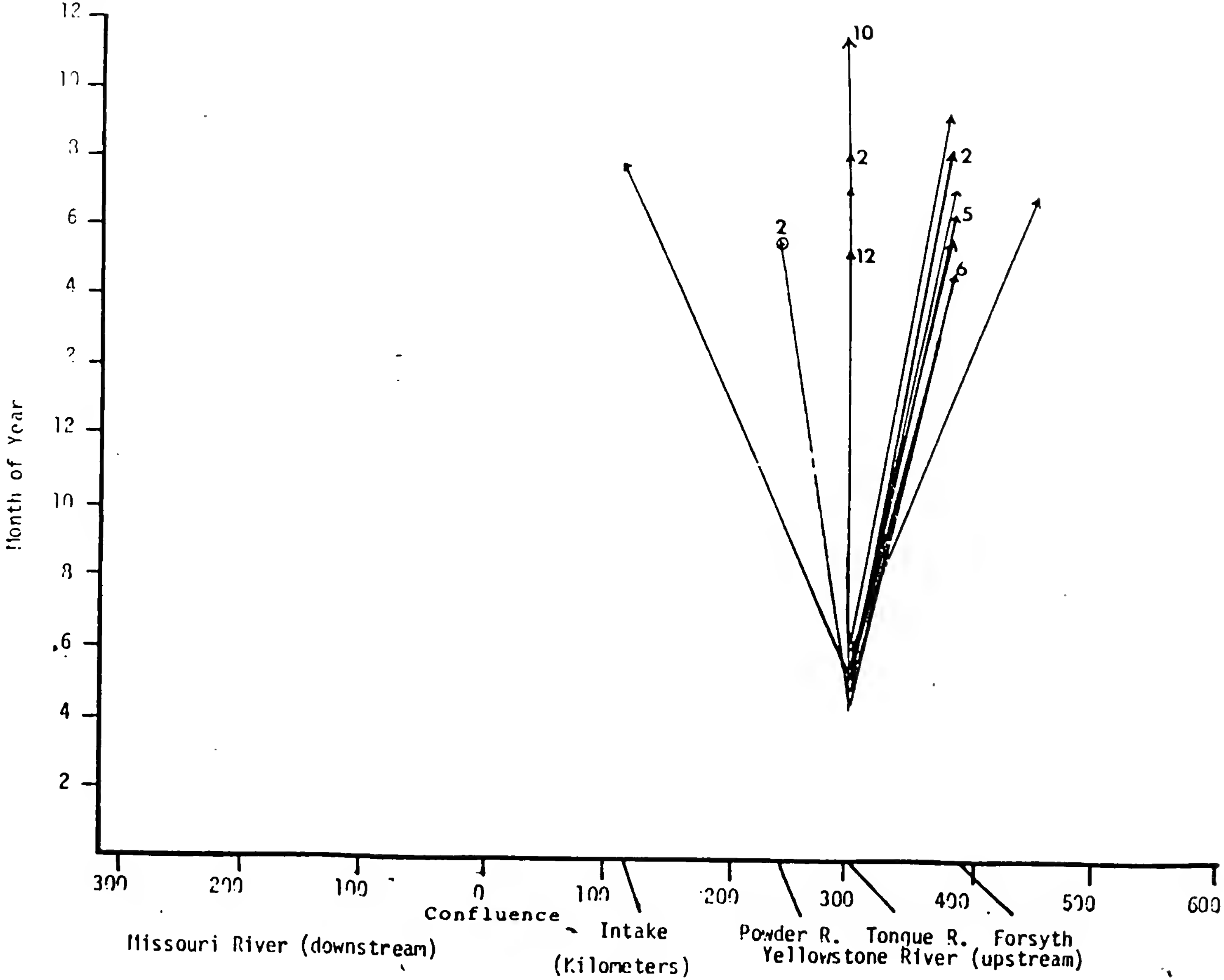

Figure A13. Movement of sauger tagged in the lower Tongue River, 1975-1979, and recaptured in the Yellowstone (___) and Powder (---) rivers in following calendar years.

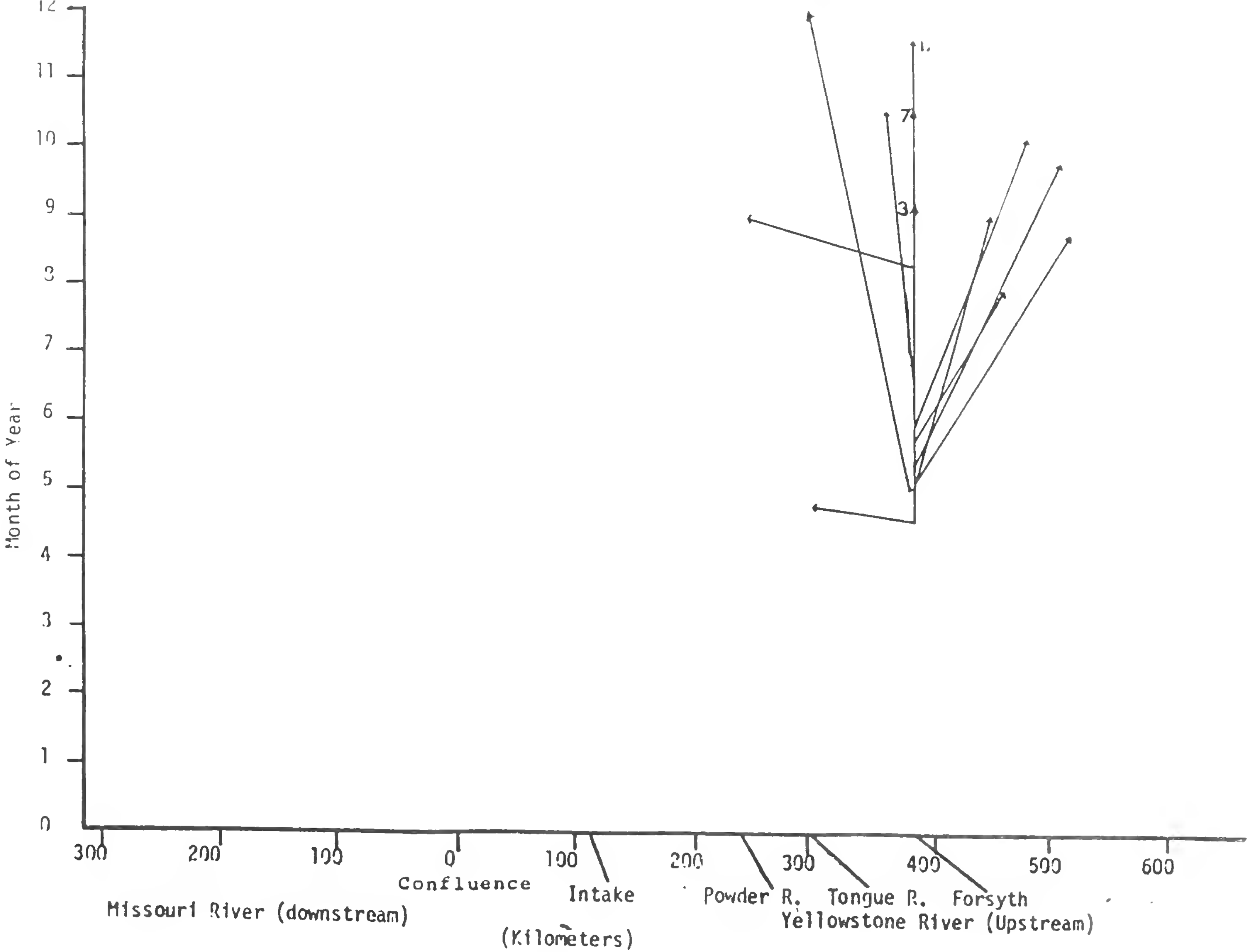

Figure A14. Movement of sauger tagged in the Yellowstone River donwstream from Forsyth diversion, 1974-1980, and recaptured in the Yellowstone River during the same calendar year.

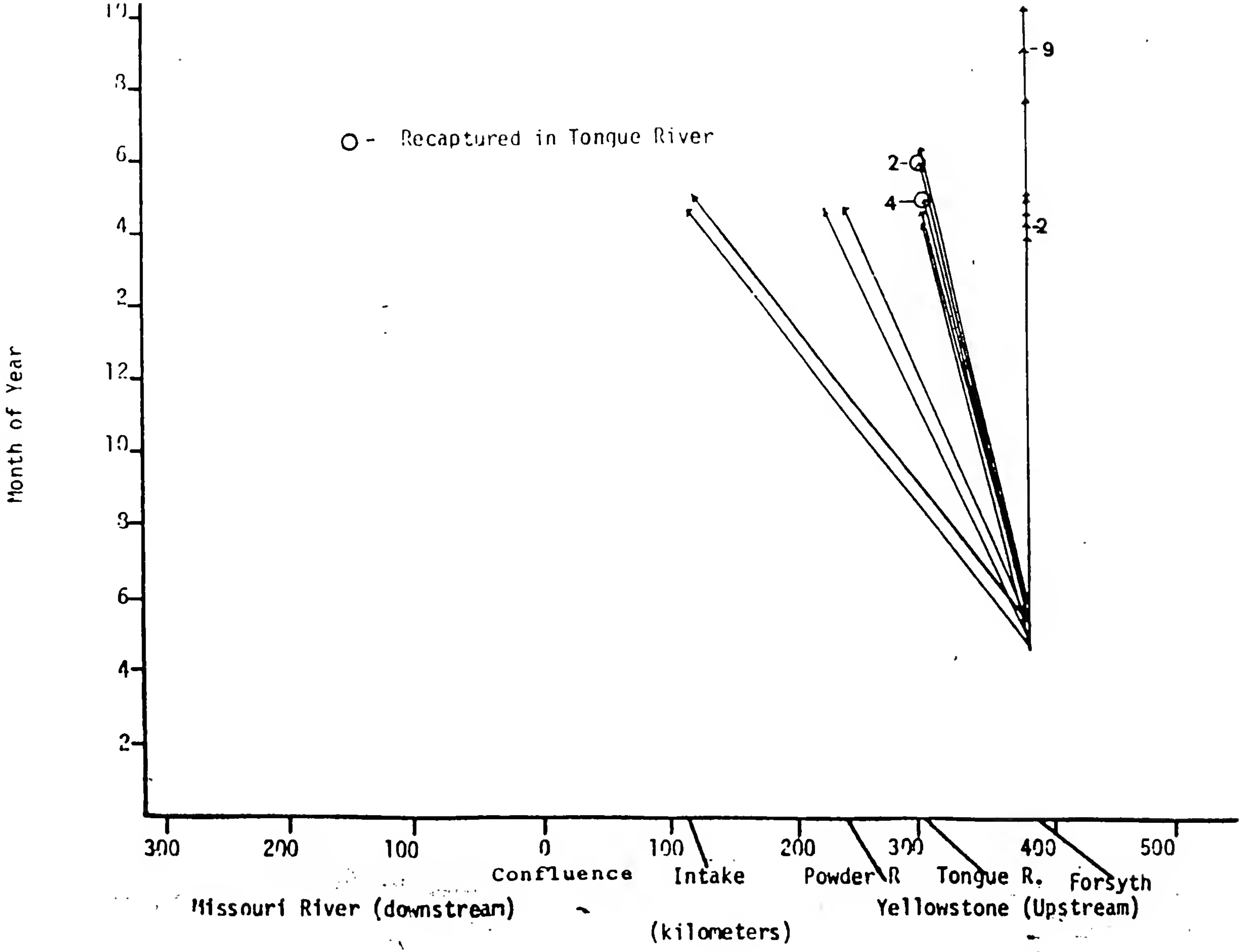

Figure A15. Sauger tagged in the Yellowstone River downstream from Forsyth diversion, 1974-1979, and recaptured in the same season of subsequent years.

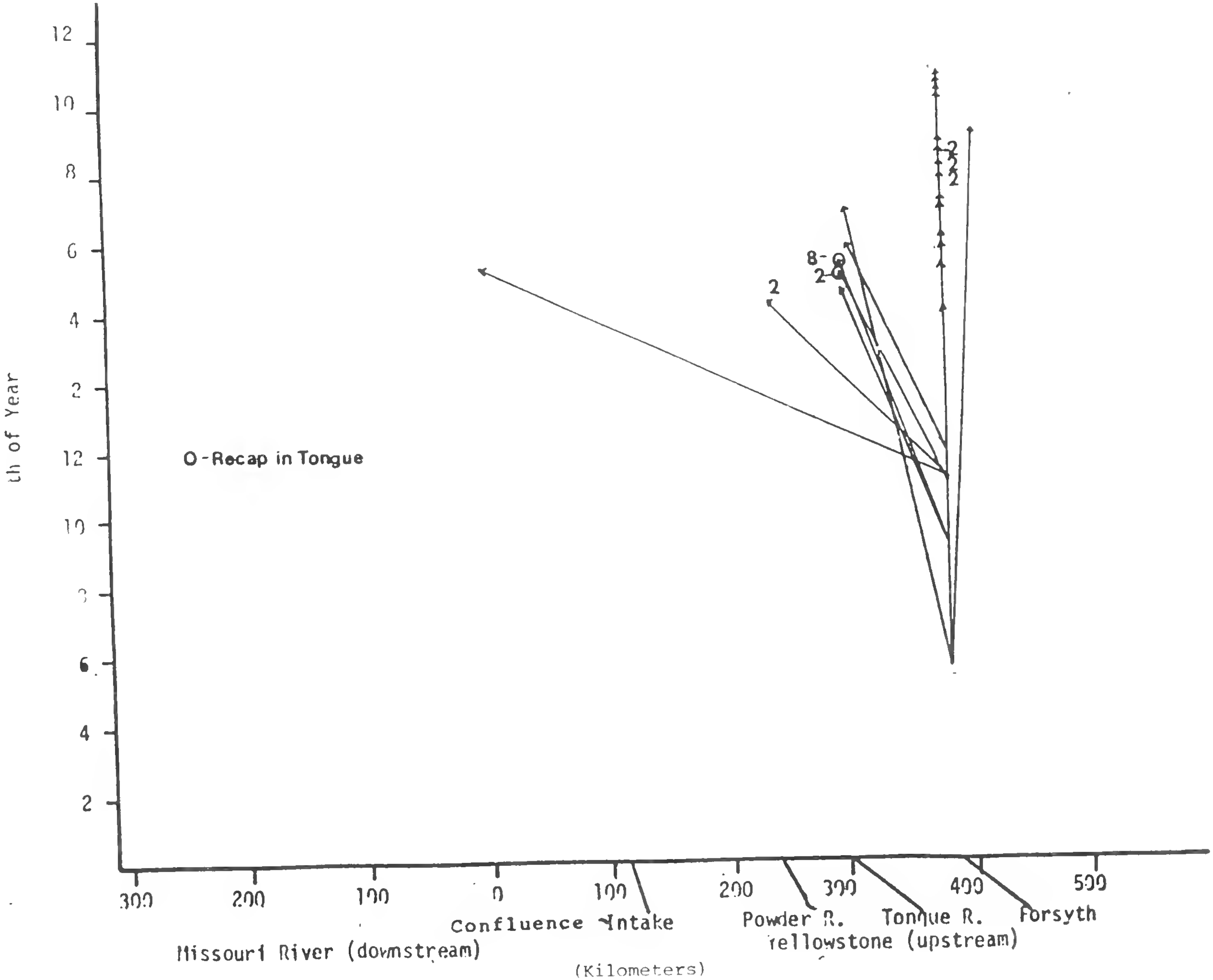

Figure A16. Movement of sauger tagged in the Yellowstone River downstream from Forsyth diversion, 1974-1979, and recaptured in a different season in subsequent years.

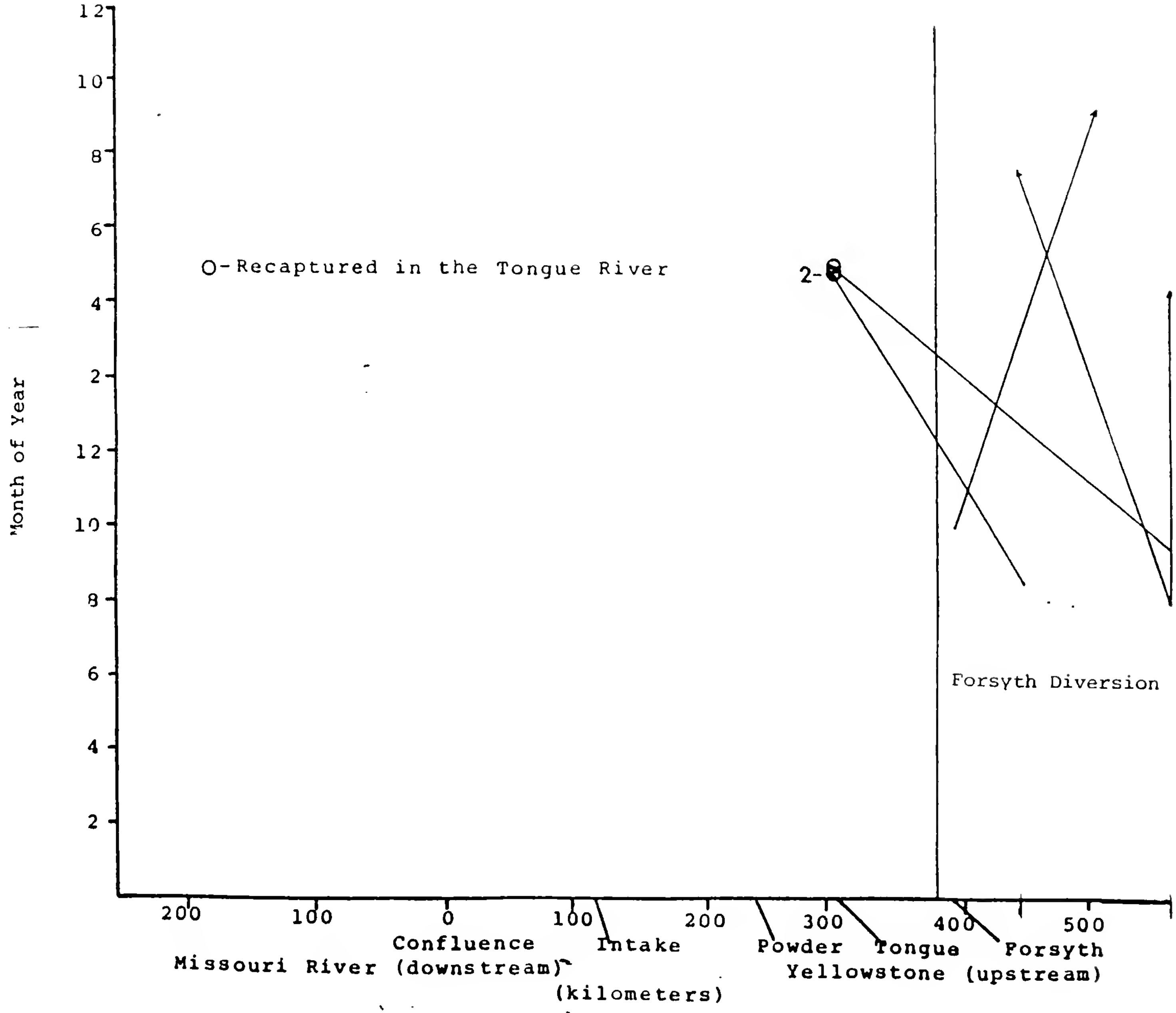

Figure A17. Movement of sauger tagged in the Yellowstone River upstream from Forsyth diversion, 1974-1979.

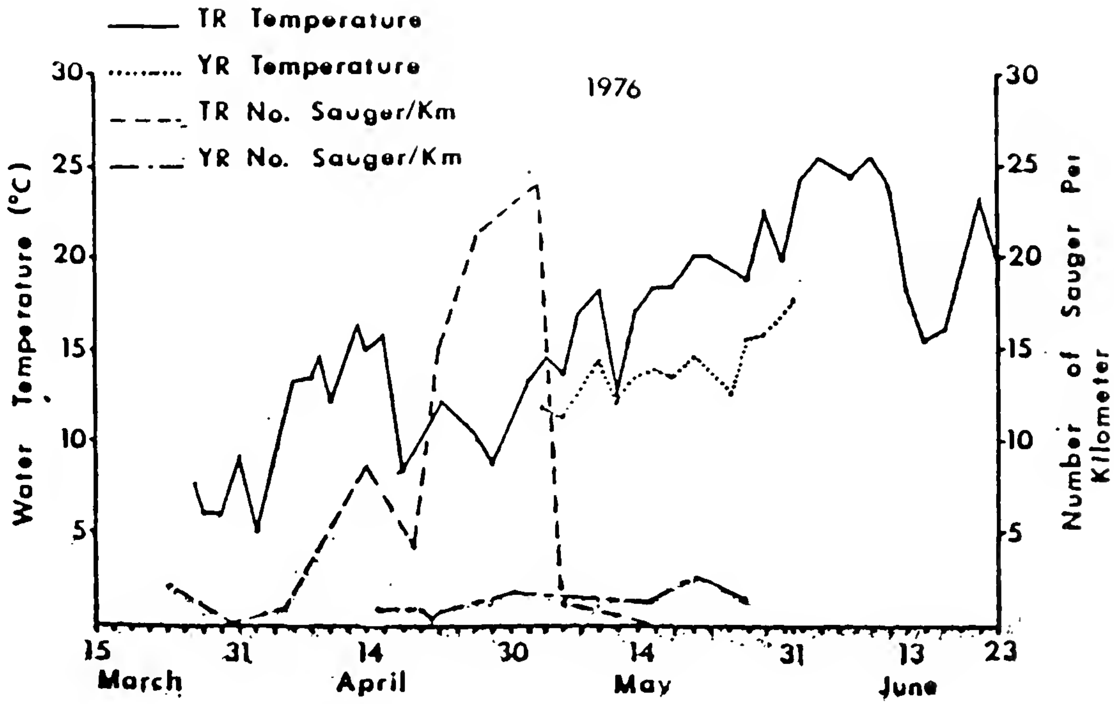

Figure A18. Catch rate of mature male sauger and mean daily water temperatures of the Tongue and Yellowstone rivers near Miles City during spring, 1976.

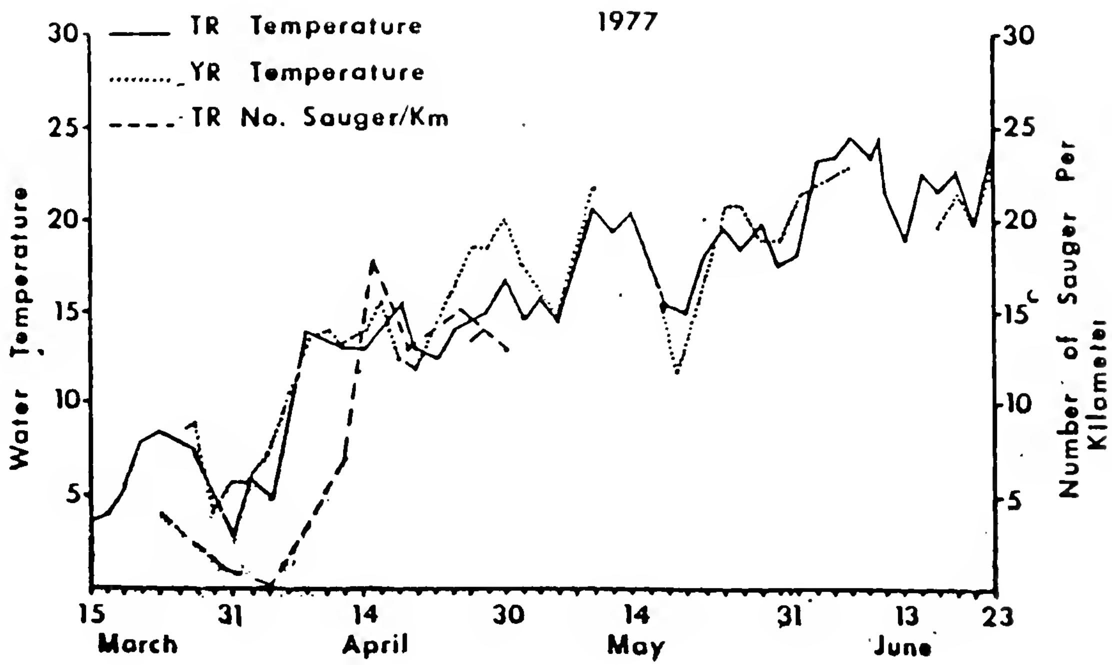

Figure A19. Catch rates of mature male sauger in the Tongue River and mean daily water temperatures of the Tongue and Yellowstone rivers near Miles City during spring, 1977.

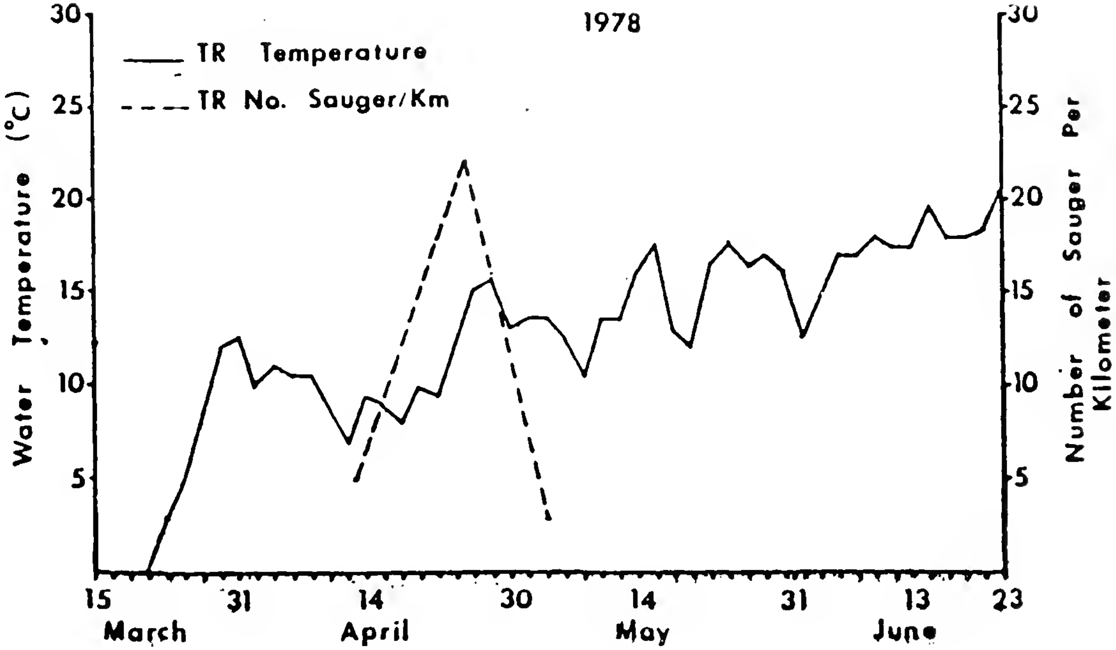

Figure A20. Catch rates of mature male sauger and mean daily water temperatures of the Tongue River near Miles City during spring, 1978.

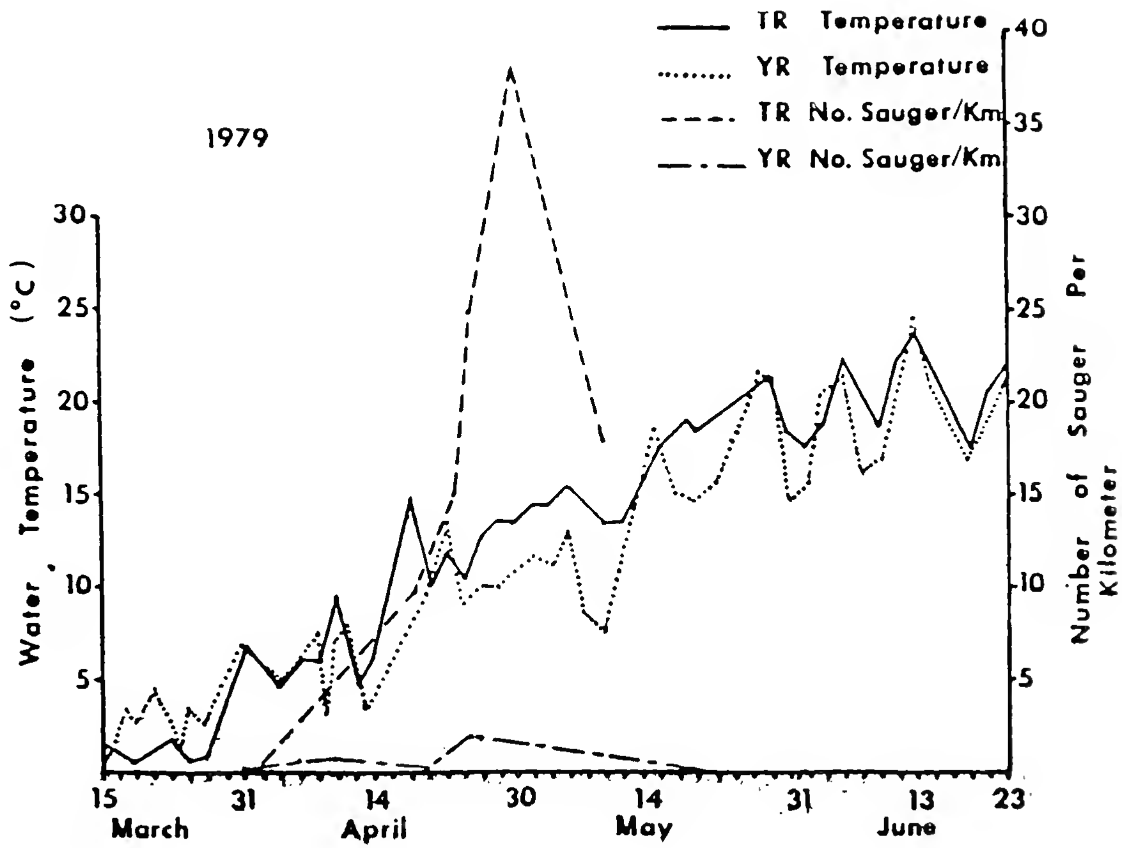

Figure A21. Catch rate of mature male sauger and mean daily water temperatures of the Tongue and Yellowstone rivers near Miles City during spring, 1979.

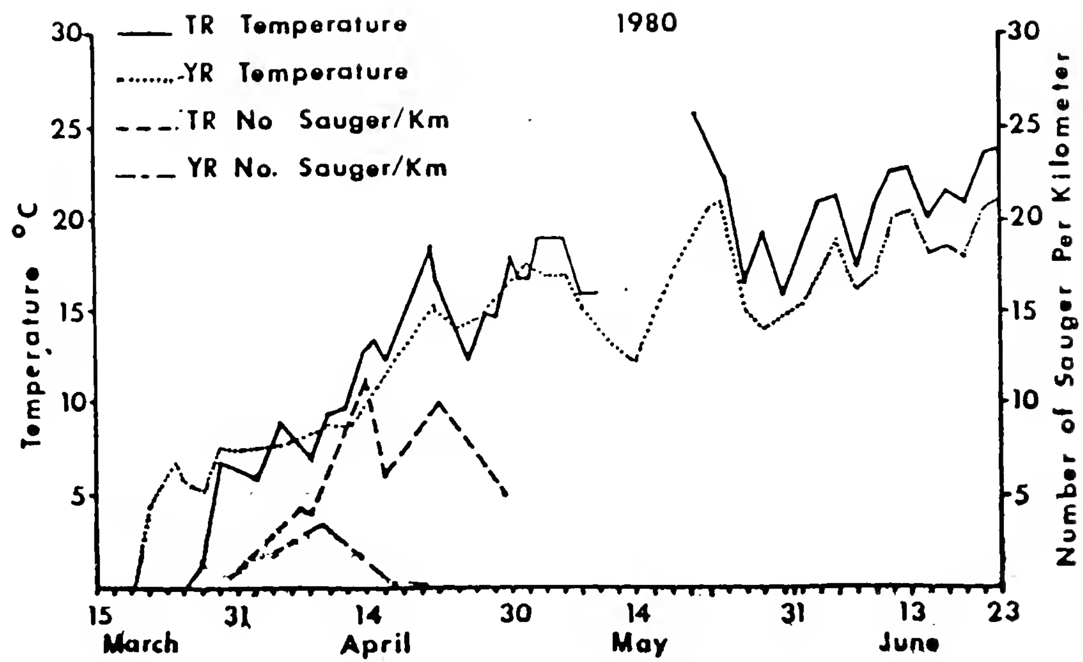

Figure A22. Catch rates of mature male sauger and mean daily water temperatures of the Tongue and Yellowstone rivers near Miles city during spring, 1980.

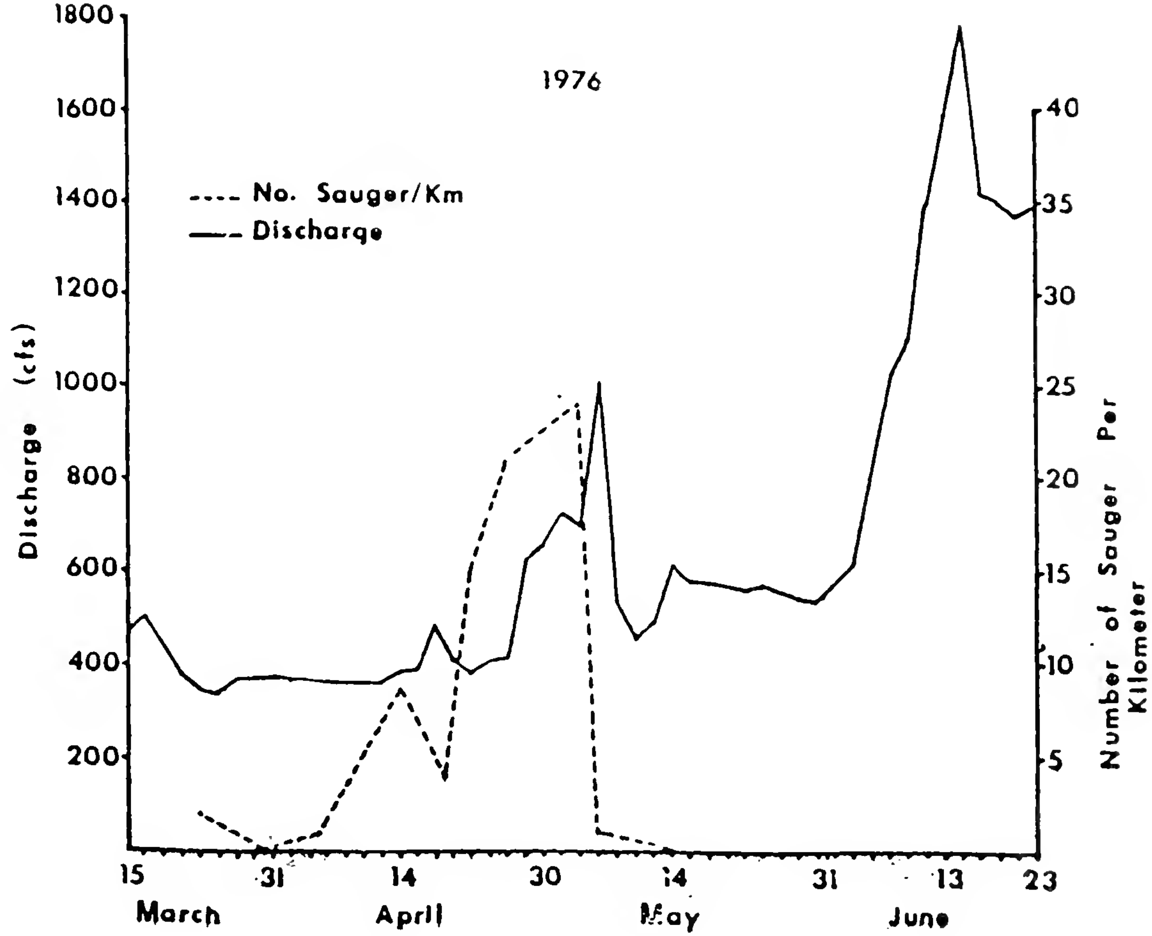

Figure A23. Catch rates of mature male sauger and mean daily discharge of the Tongue River near Miles City, 1976.

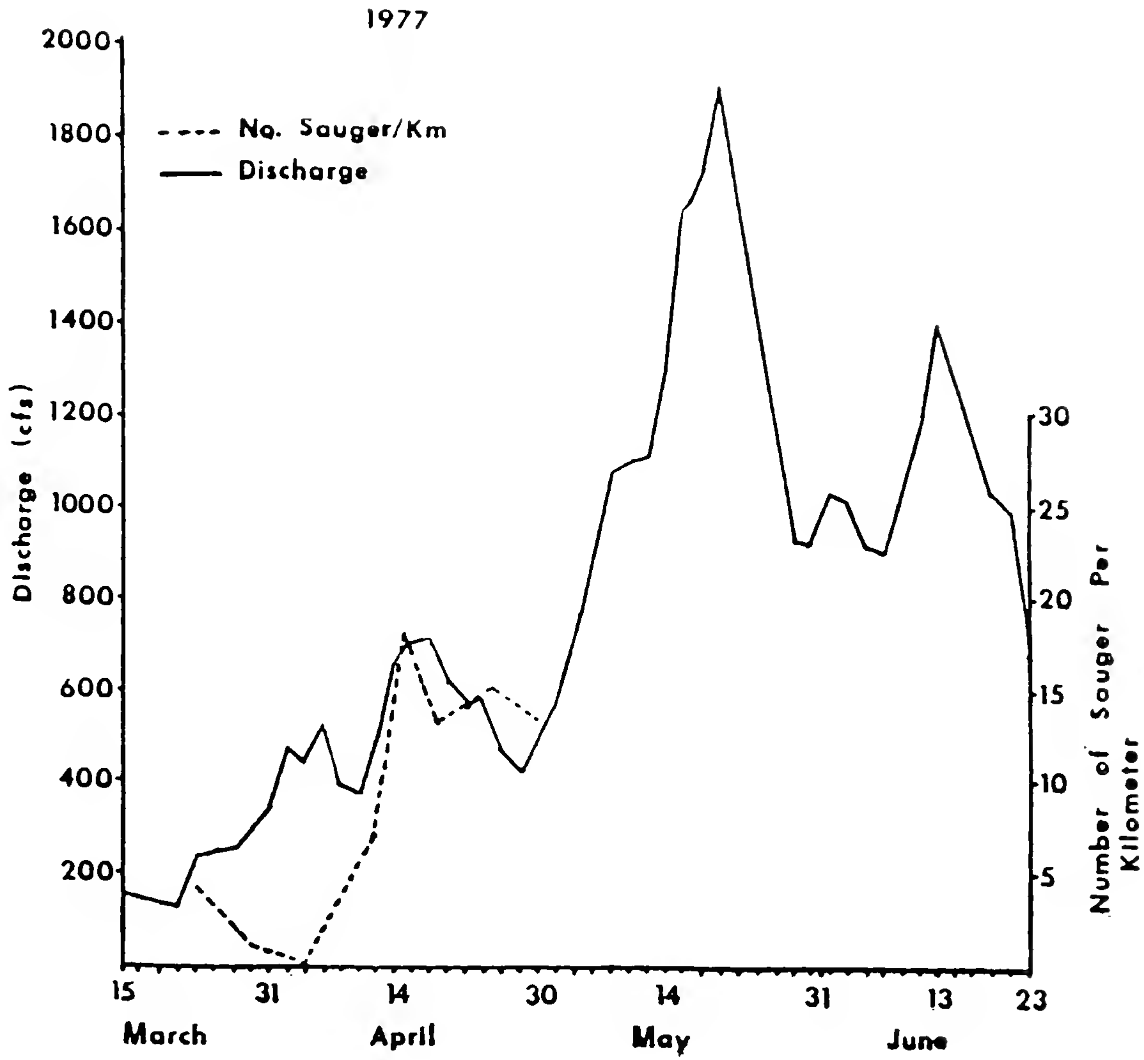

Figure A24. Catch rates of mature male sauger and mean daily discharge of the Tongue River near Miles City, 1977.

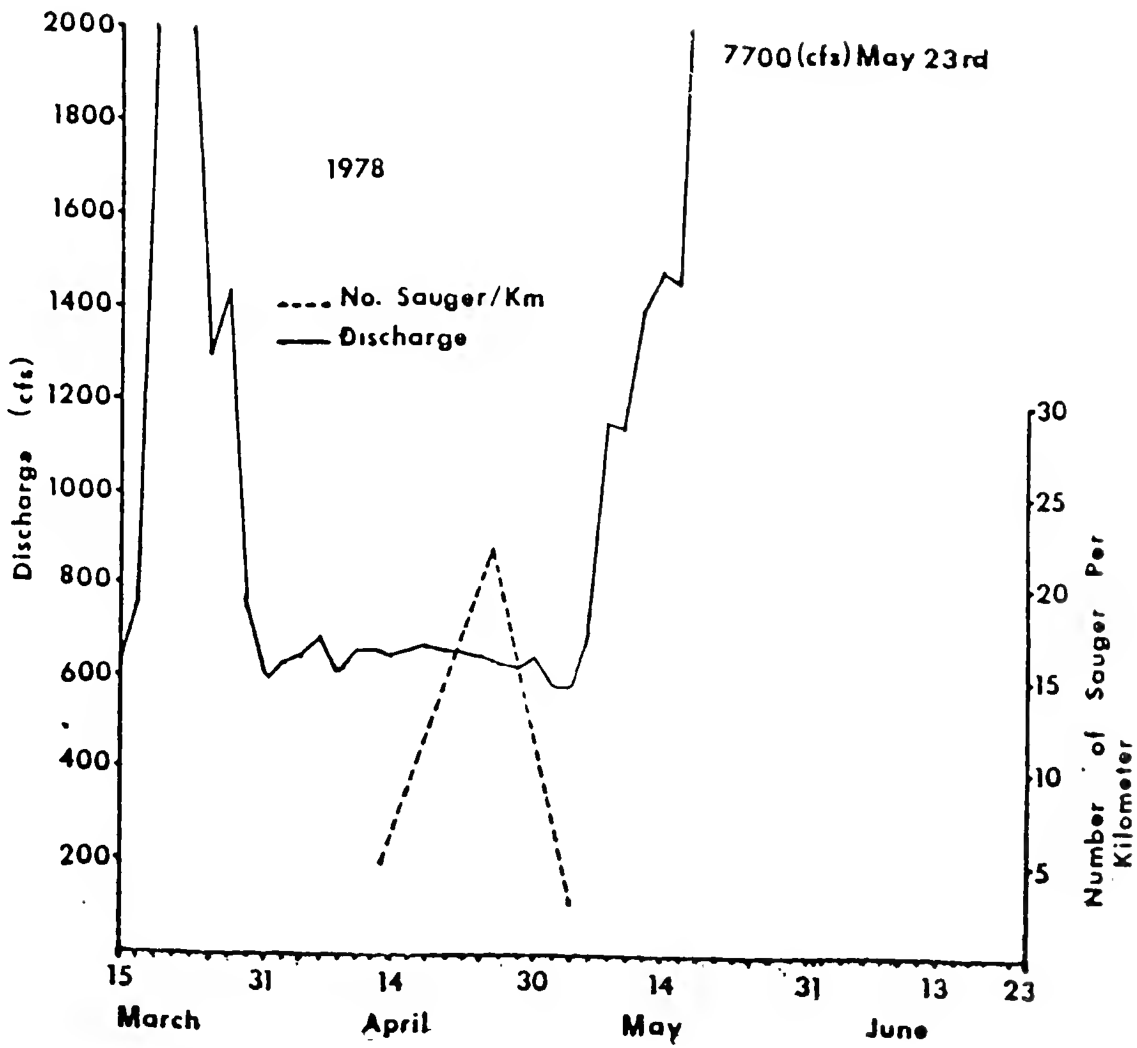

Figure A25. Catch rates of mature male sauger and mean daily discharge of the Tongue River near Miles City, 1978.

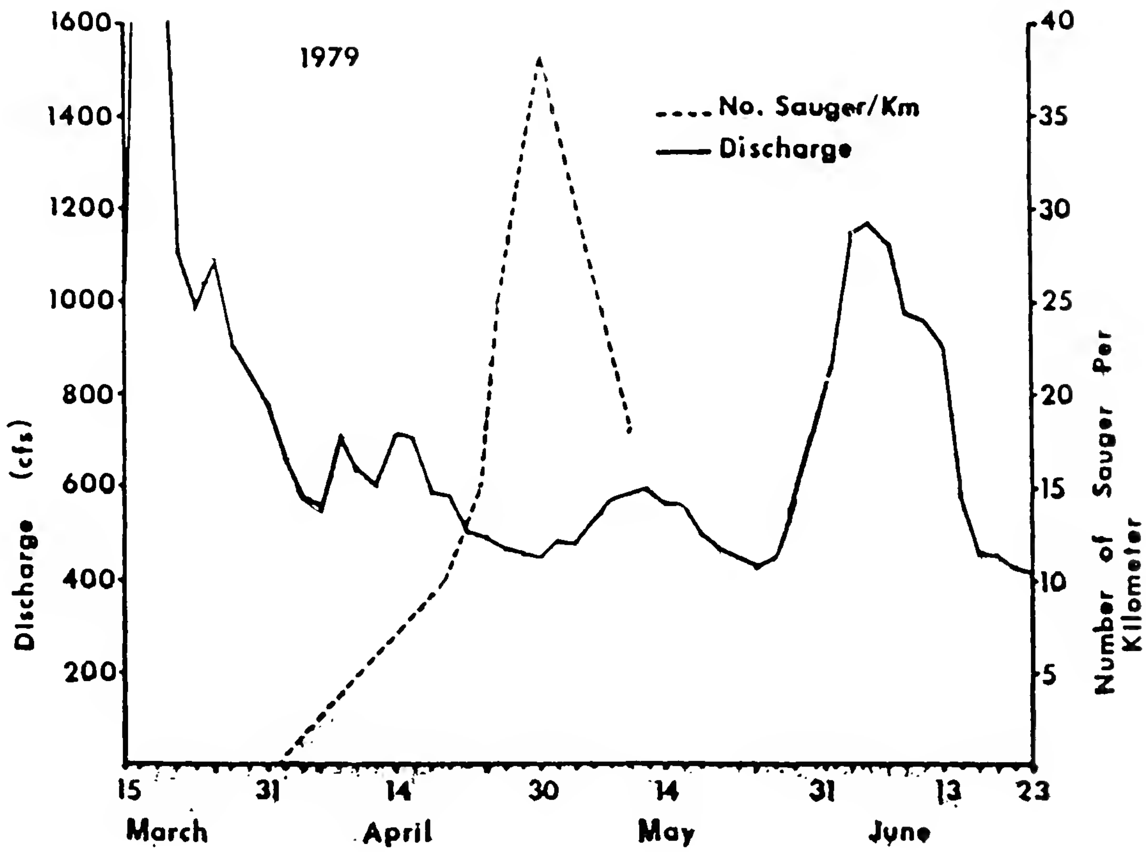

Figure A26. Catch rates of mature male sauger and mean daily discharge of the Tongue River near Miles City, 1979.

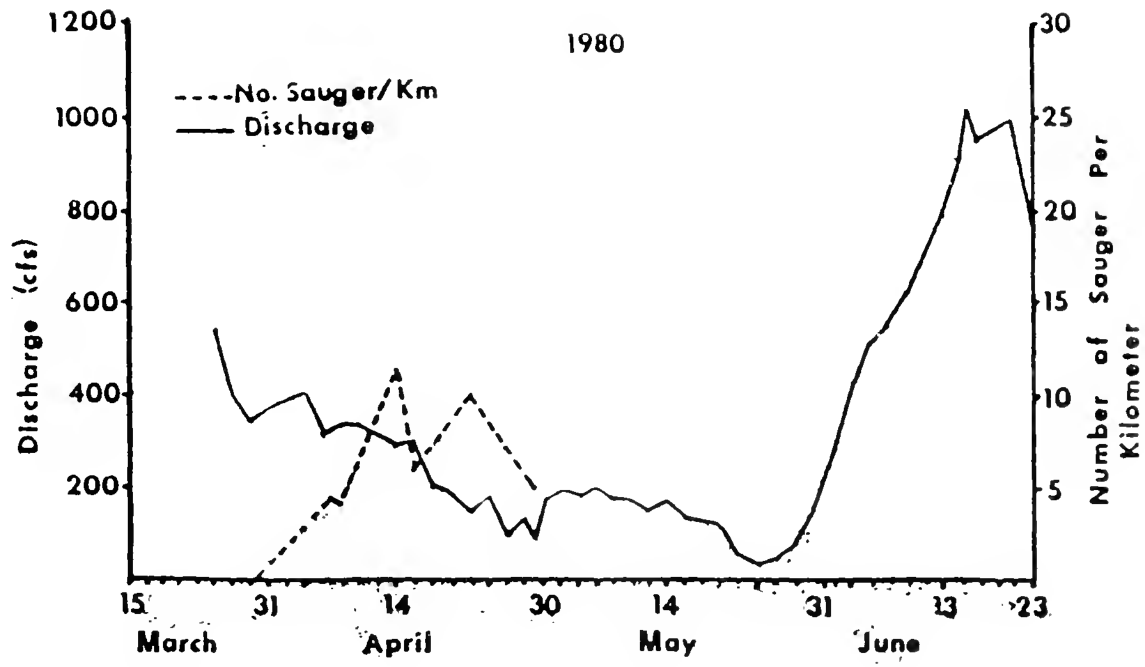

Figure A27. Catch rates of mature male sauger and mean daily discharge of the Tongue River near Miels City, 1980.

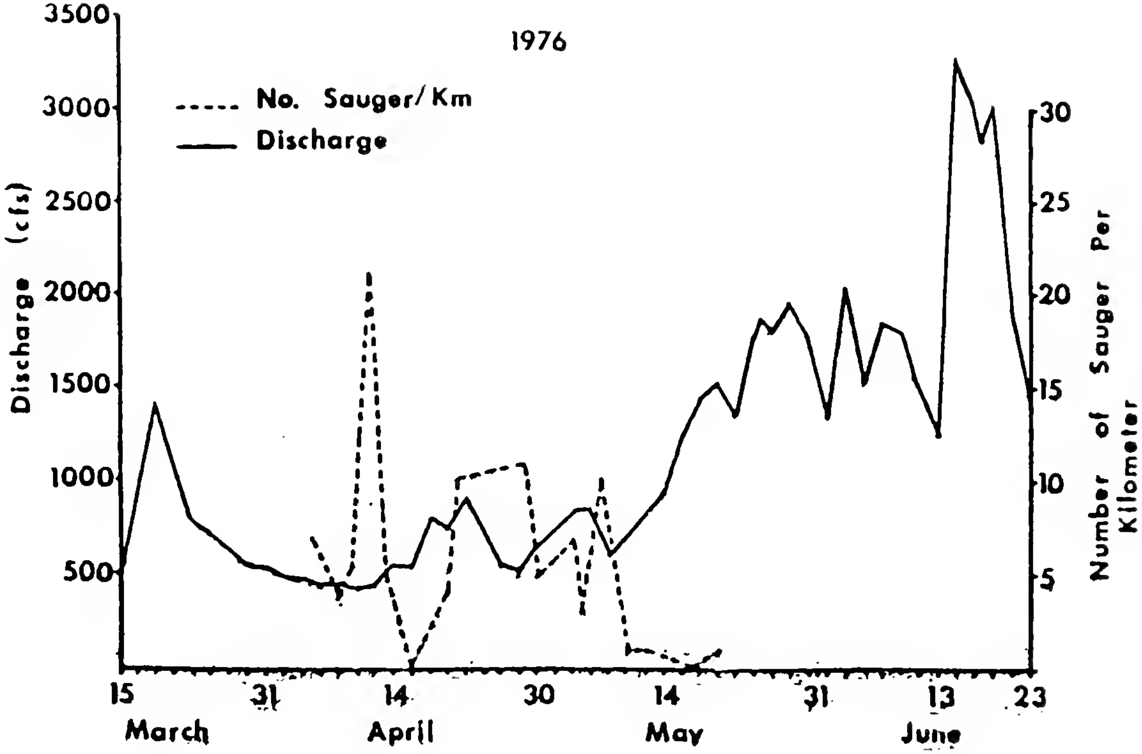

Figure A28. Catch rate of mature male sauger and mean daily discharge of the Powder River during spring, 1976.

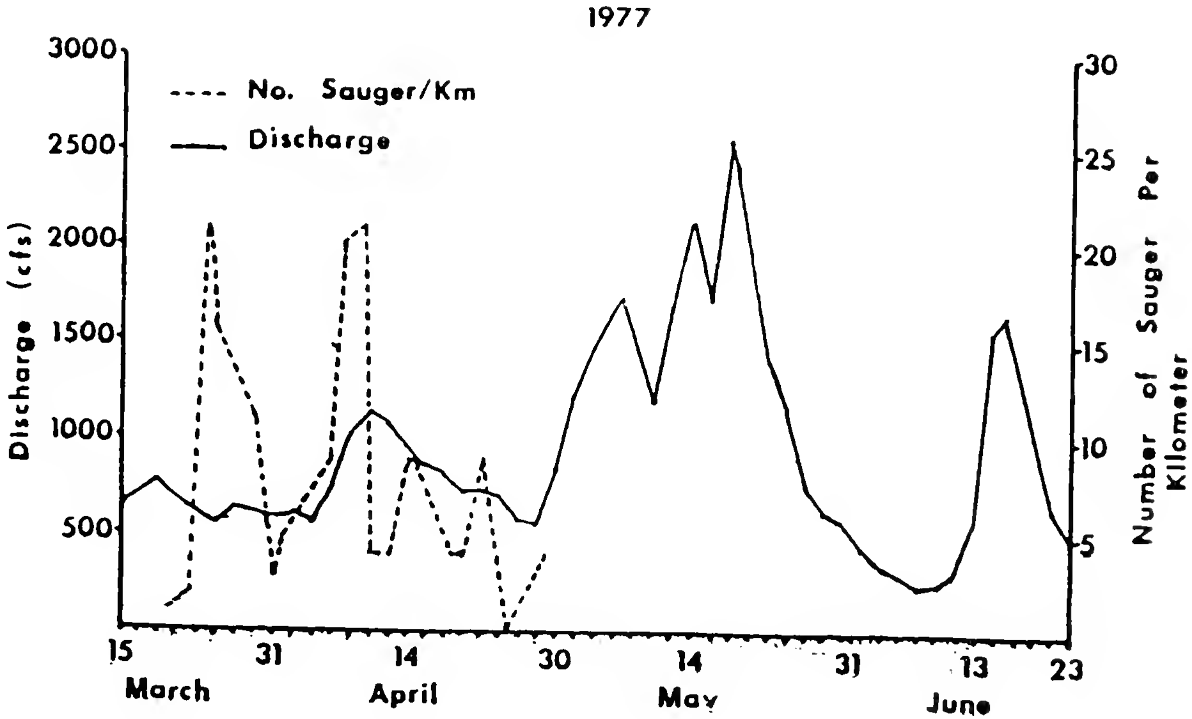

Figure A29 Catch rate of mature male sauger and mean daily discharge of the Powder River during spring, 1977.

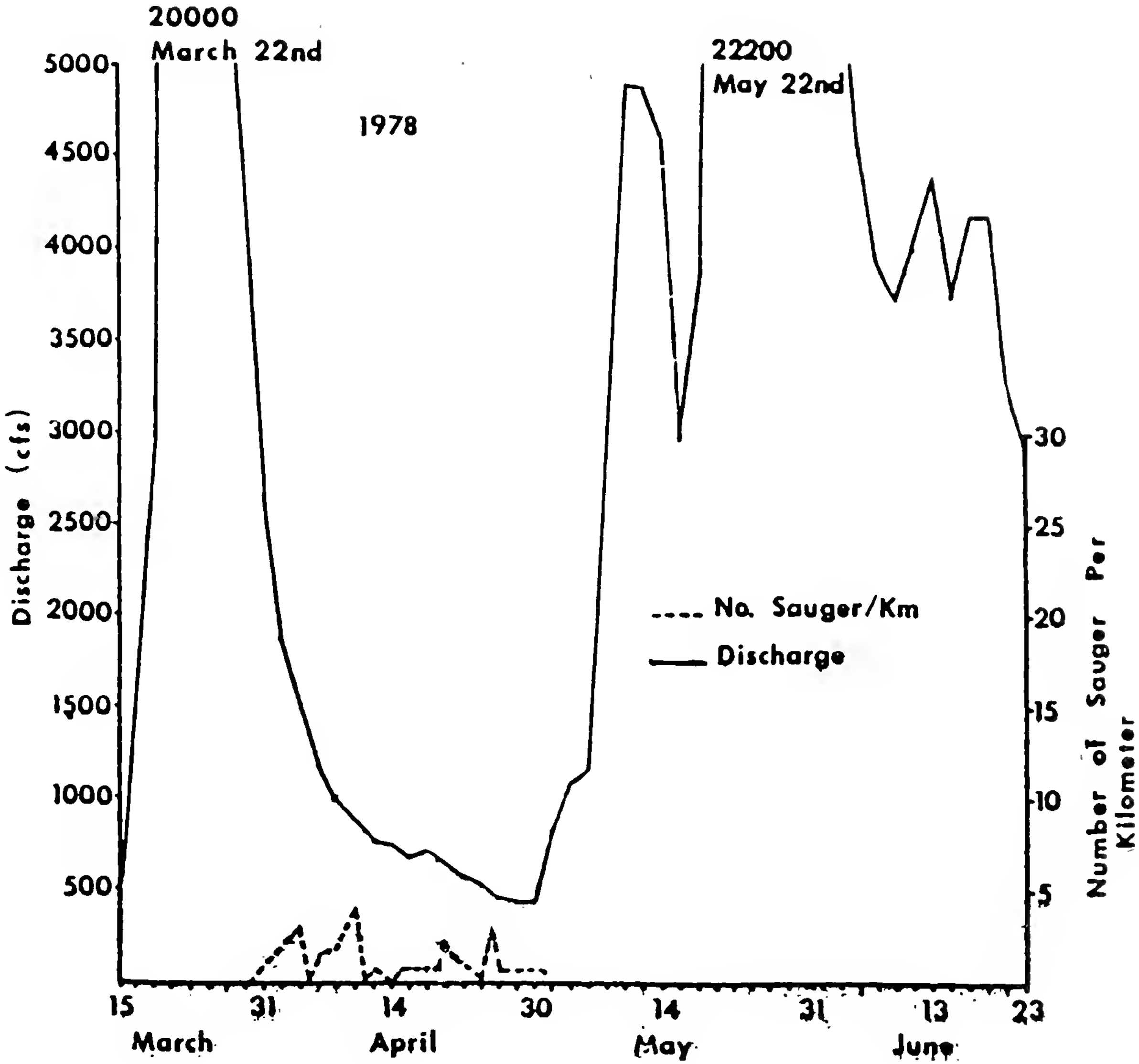

Figure A30. Catch rate of mature male sauger and mean daily discharge of the Powder River during spring, 1978.

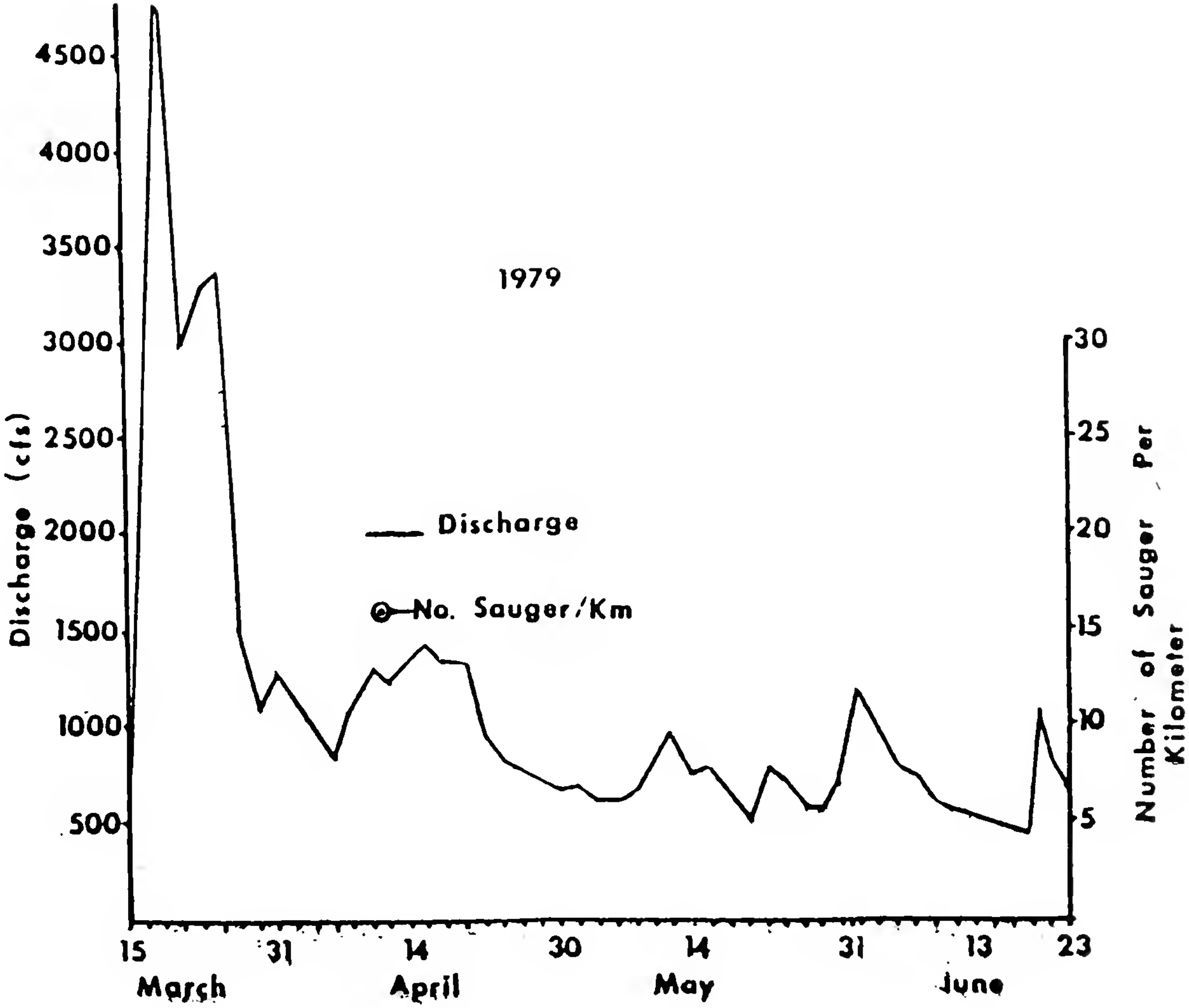

Figure A31. Catch rates of mature male sauger and mean daily discharge of the Powder River during spring, 1979.

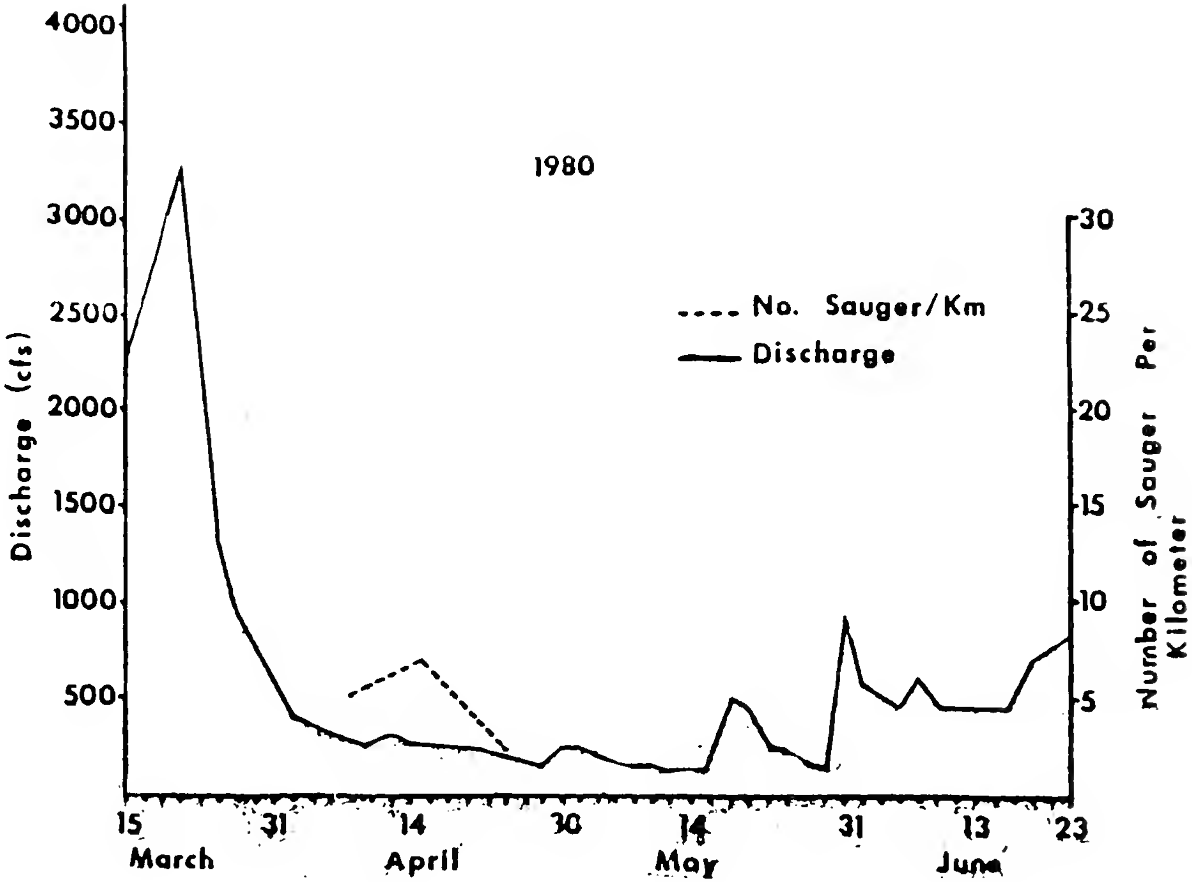

Figure A32. Catch rate of mature male sauger and mean daily discharge of the Powder River during spring, 1980.

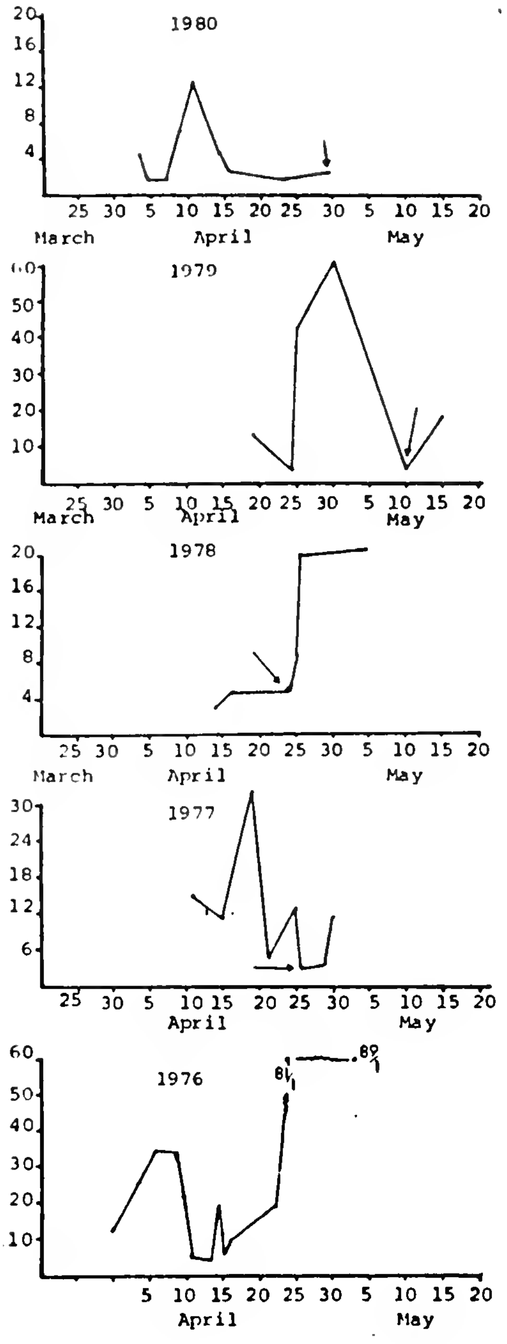

Figure A33. Sex ratio (males:females) of sauger collected in the lower Tongue River during spring, 1976-1979. Arrows indicate date that the first ripe or spent females were collected.

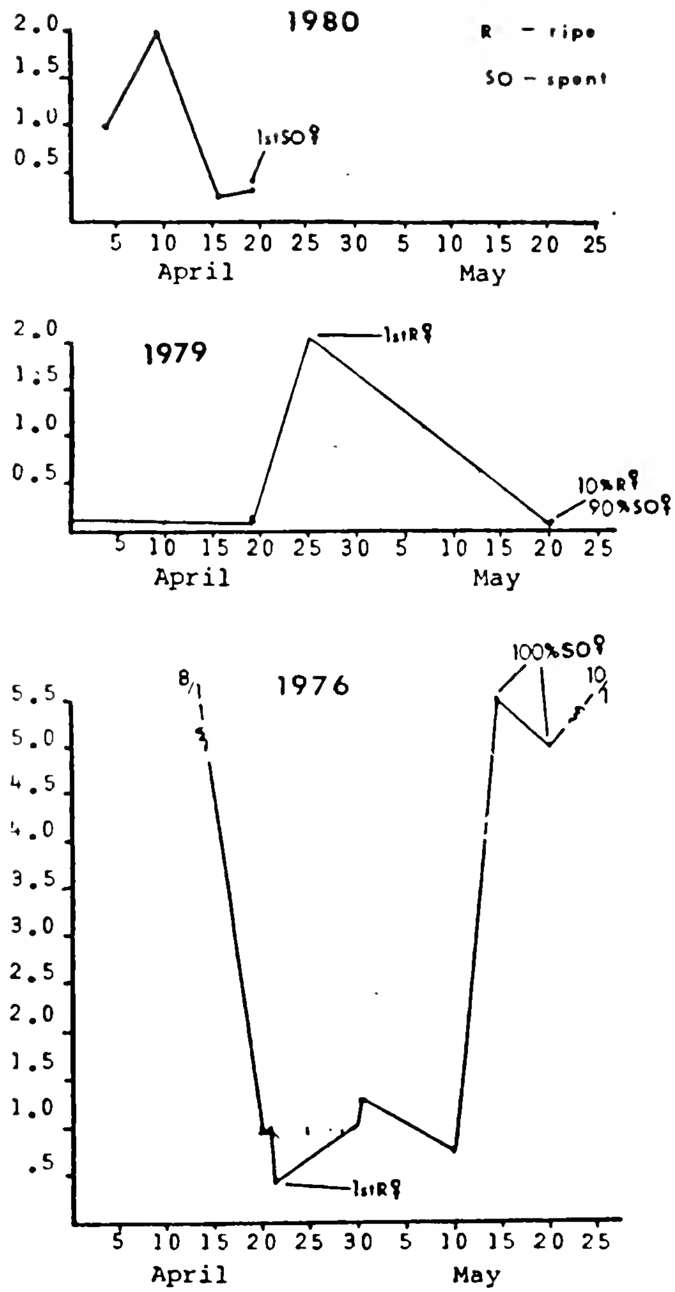

Figure A34. Sex ratio (males:females) of mature sauger captured while electrofishing the Yellowstone River near Miles City during the spring of 1976, 1979 and 1980.

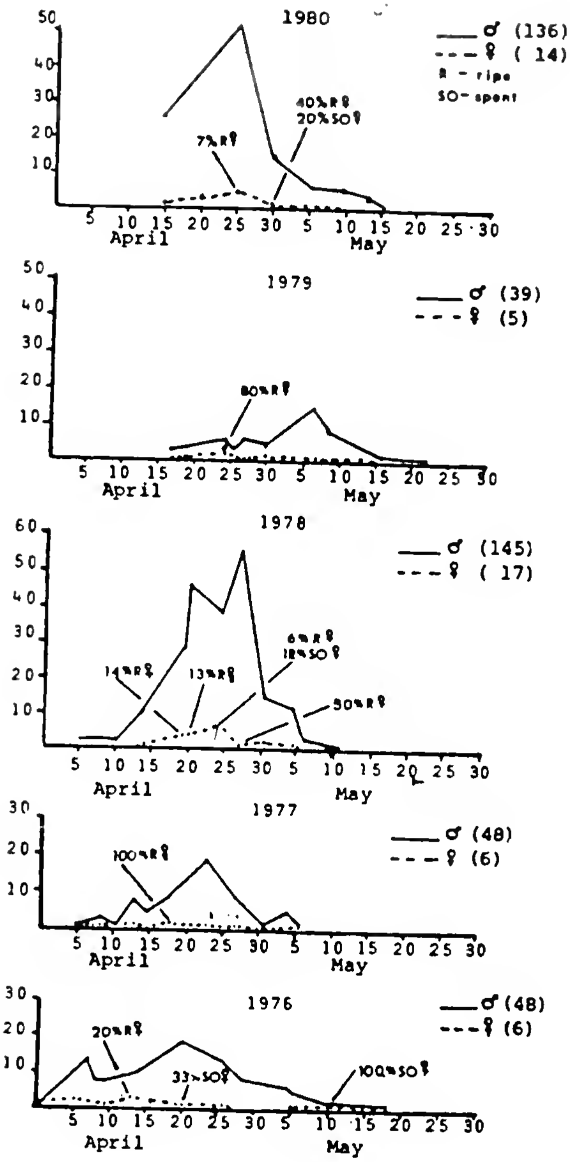

Figure A35. Number of walleye captured per kilometer while electrofishing the Yellowstone River downstream from Intake diversion during spring, 1976-1980. The maximum number of walleye collected during one sample run is in parenthesis.