MONTANA DEPARTMENT OF FISH, WILDLIFE AND PARKS
FISHERIES DIVISION

JOB PROGRESS REPORT

STATE: MONTANA **PROJECT TITLE: Statewide Fisheries Investigations**

PROJECT: F-78-R-5 **STUDY TITLE: Survey and Inventory of Warmwater Streams**

JOB NO: III-B **JOB TITLE: Southeast Montana Warmwater Streams Investigations**

PROJECT PERIOD: July 1, 1998 through October 2010

ABSTRACT

The Yellowstone River fish assemblage was sampled annually each autumn with boat-mounted electrofishing equipment since 1998. Trend areas consisted of 5 different locations; Forsyth (downstream of Cartersville Diversion), Miles City (above and below the Tongue River confluence), Fallon (above and below the O' Fallon Creek confluence), Intake (downstream of Intake Diversion) and since 2003, Hysham (downstream of Rancher diversion). Trend areas are approximately 9.6 river km in length and are sampled once in August, September and October. All species encountered are collected, enumerated, measured, and, excepting cyprinids, weighed. An index of abundance (catch per effort) was calculated for all species captured.

Catch per effort was calculated by trend section for sauger, channel catfish, and smallmouth bass. Indices of population structure (incremental relative stock density) and condition (relative weight) were calculated for sauger, channel catfish, smallmouth bass, shovelnose sturgeon, burbot, and walleye. Environmental conditions varied widely during the study period; average flows occurred during 1998 and 1999, drought conditions and low flows occurred during 2000 to 2007 and average to above average flows returned in 2008 to 2010. The fish assemblage appeared to withstand the drought conditions and responded well when average/above average flows returned in 2008. Since 1998, 42 different species have been captured and abundances of commonly collected species from all trophic guilds remained stable or increased. Catch rates of multiple species including sauger and catfish were at all time high levels during the 2010 trend survey. Blue sucker abundances fluctuated annually but the trend remained stable through the duration of the study. Excellent angling opportunities currently exist for sauger, channel catfish, smallmouth bass, and shovelnose sturgeon.

STUDY AREA

The study area consists of the 473 km of the Yellowstone River downstream of the Big Horn River confluence (Figure 1). Mean annual discharge at the USGS gauging station in Miles City, Montana, is 317 m^3/s and mean annual peak discharge is 1459 m^3/s (Figure 2). River geomorphology varies throughout the study area in direct response to valley geology; straight, sinuous, braided, and irregular-meander channel patterns occur (Silverman and Tomlinsen 1984). The channel is often braided or split and long side channels are common. Islands and bars range from large vegetated islands to unvegetated point and mid-channel bars (White and Bramblett 1993). Substrate is primarily gravel and cobble upstream of river kilometer 50 and is primarily fines and sand below (Bramblett and White 2001). The fish assemblage is comprised of 49 species from 15 families, including eight state-listed Species of Special Concern and one federally listed endangered species (White and Bramblett 1993; Carlson 2003). The primary deleterious anthropogenic effect on the fish assemblage is water withdrawal for agriculture and associated entrainment of fish (White and Bramblett 1993). About 90% of all water use on the Yellowstone River is for irrigation, which corresponds to annual use of 1.5 million acre-feet (White and Bramblett 1993). Six mainstem low-head irrigation diversions dams occur in the study area. The largest and downstream-most of these, Intake Diversion, diverts about 38 m^3/s and entrains about 600,000 fish of 34 species during the mid-May to mid-September irrigation season (Hiebert et al. 2000).

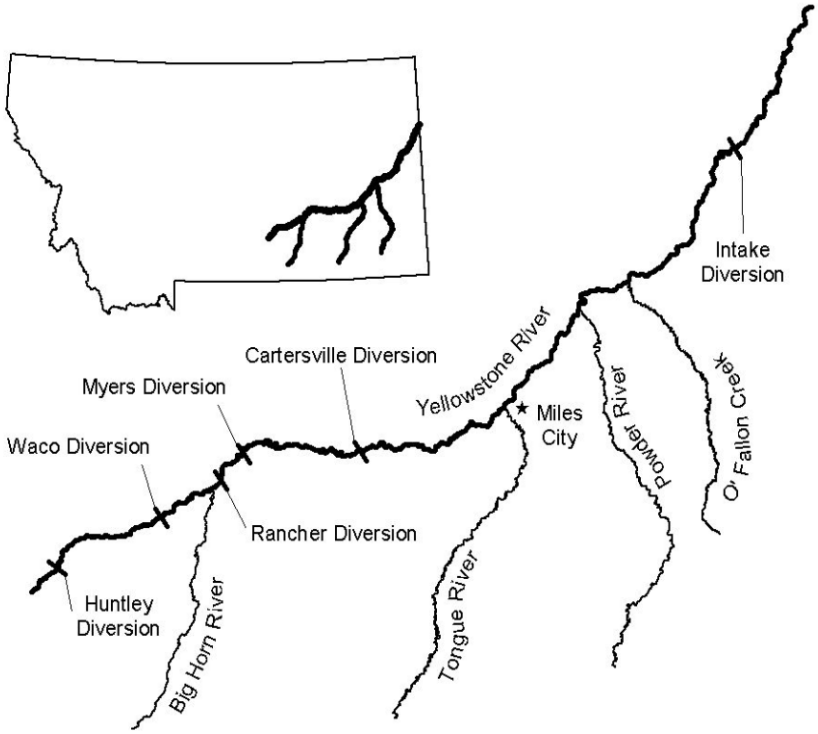


Figure 1. The Yellowstone River, its major tributaries, and diversion dams.

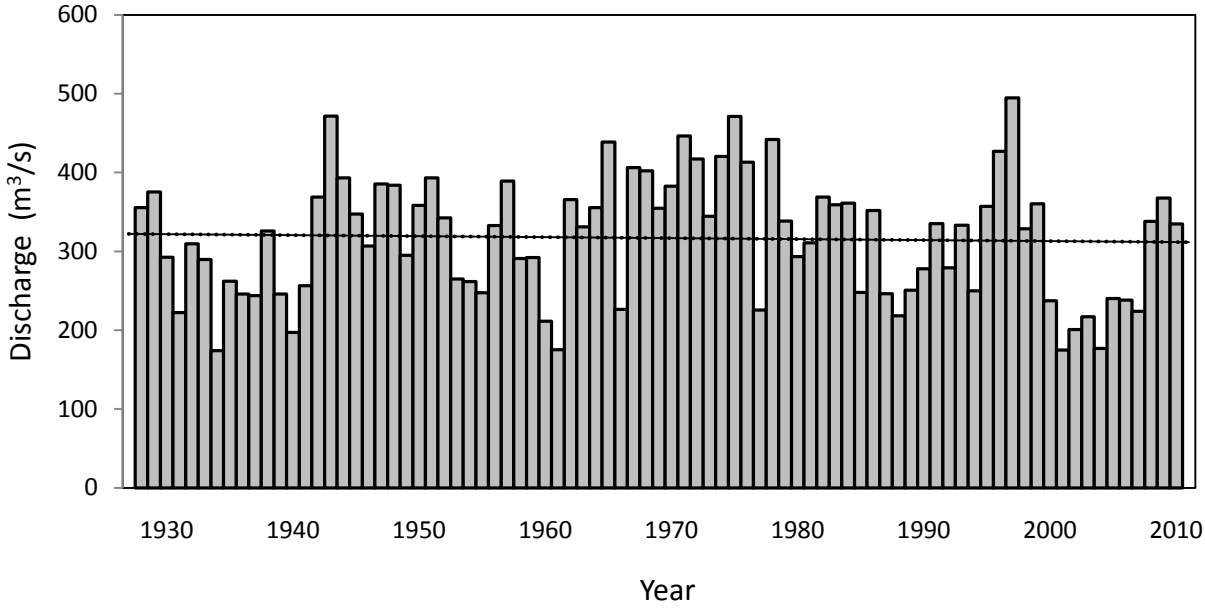


Figure 2. Mean annual discharge of the Yellowstone River at Miles City, 1929-2010. Dashed line represents mean annual discharge (317 m3/s) calculated since 1927.

METHODS

The Yellowstone River fish assemblage was sampled each autumn with boat-mounted electrofishing equipment. Coffelt electrofishing equipment was used in all years except when Smith-Root equipment was used in 2008 and 2010. Sampling occurred in the following five trend areas: Forsyth (downstream of Cartersville Diversion), Miles City (above and below the Tongue River confluence), Fallon (above and below the O' Fallon Creek confluence), Intake (downstream of Intake Diversion) and since 2003, Hysham (downstream of Rancher diversion). Trend areas are approximately 9.6 river km in length. All species encountered were collected, enumerated, measured (fork length for sturgeon and total length for all other species), and if length was greater than 120 mm, weighed.

An index of abundance (catch per effort) was calculated for all species captured. Catch per effort was also calculated by trend section for sauger, channel catfish, and smallmouth bass. Indices of population structure (incremental relative stock density) and condition (relative weight) were calculated for sauger, channel catfish, smallmouth bass, shovelnose sturgeon, burbot, and walleye (Anderson and Neuman 1996). Population structure and condition for these species were described using 1) only data from autumn trend sampling (autumn trend data) and 2) all data collected during a given year (all data). Autumn trend data are less biased and provide the best insight into population structure and condition among years because consistent timing, location, and methodology occur during this study period. However, low catch rates of some species during autumn trend surveys preclude making inferences. In these instances inclusion of all data was helpful.

RESULTS AND DISCUSSION

To date, 42 different species have been captured. Catch by section is summarized in Appendix 1. Conditions varied widely during the study period; average to above average flows occurred in 1998, 1999 and 2008 to 2010. Drought conditions and low flows occurred during 2000 to 2007 (Figure 2). The fish assemblage appeared to withstand drought conditions well. Abundances of commonly collected species from all trophic guilds remained stable or increased. Catch rates of multiple species including sauger and catfish were at all time highs during the 2010 trend survey. Population structure and size-specific condition of sauger, channel catfish, smallmouth bass, and shovelnose sturgeon were consistent among years. Electrofishing gear varied during the duration of the study. High variability between sampling condition and year is inherent; therefore, trends observed for populations over time were more useful than trends in any given year.

Sauger

Sauger were the most commonly observed game fish and catch rates averaged over 7 fish per hour from 1998 to 2010 excluding 1999 (Figure 3). Catch rates averaged about 12 fish per hour in the 1970s and 1980s but declined to about 2 fish per hour from 1990 to 1997, leading to the listing of sauger as a Species of Special Concern in Montana (McMahon and Gardner 2001). Catch rates have improved and are greater than pre-decline levels. Catch rates of over 10 fish per hour were observed in six of the last ten years and the population is trending upwards. Catch rates of about 10 fish per hour support a good sauger fishery (McMahon 1999). Catch rates in 2008 and 2010 were over 21 and 23 fish per hour respectively. High average catch rates observed were inflated by the trend area downstream of Intake Diversion. Increased catch rates above 10 fish per hour occurred in multiple survey reaches in 2008 and 2010. Sauger catch rate downstream of Intake Diversion was a historic high, 76 fish per hour in 2010 (Figure 4).

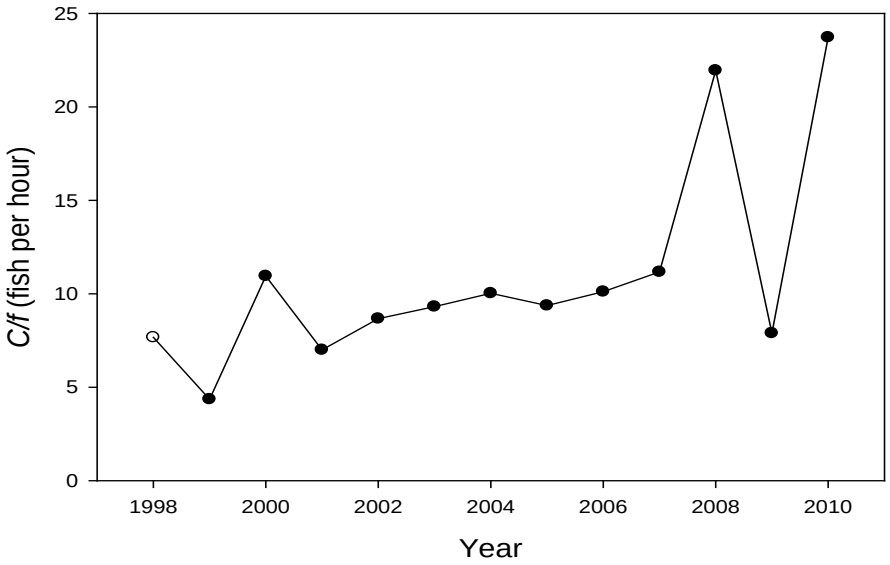


Figure 3. Catch per effort of sauger in the Yellowstone River, 1998 to 20

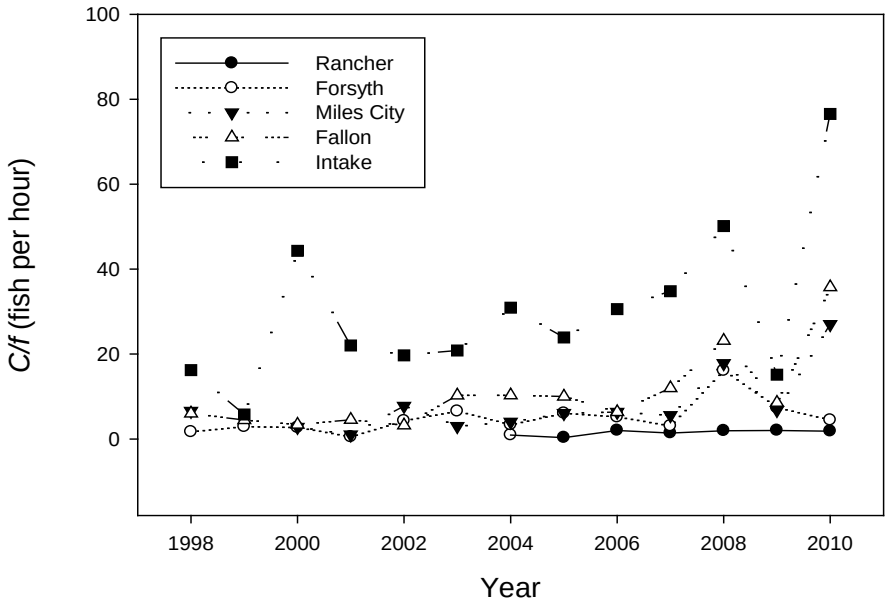
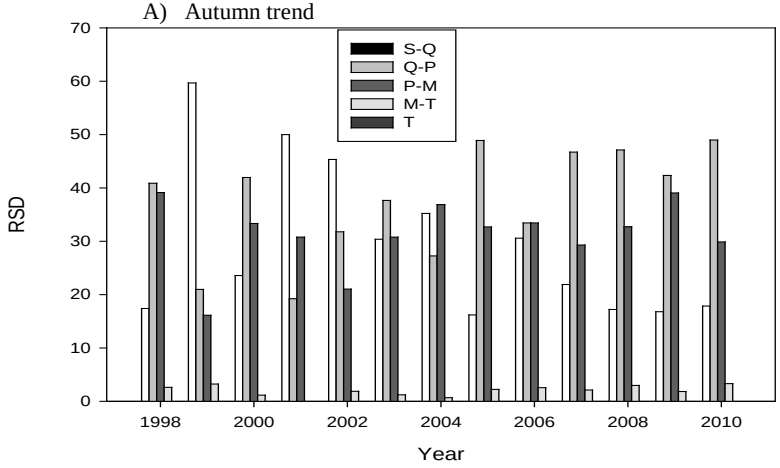


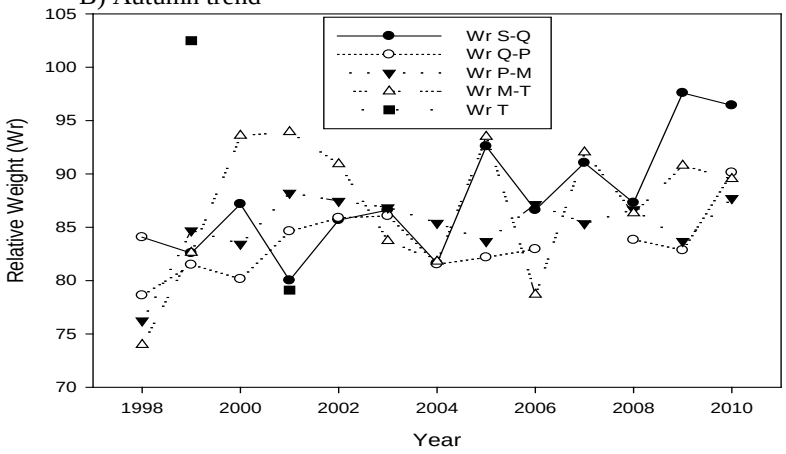
Figure 4. Catch per effort of sauger in the Yellowstone River by trend area, 1998 to 2010.

Population structure was balanced from 1998 to 2010 but skewed towards larger fish (Figure 5 A, C). It is likely that this sampling regime (autumn electrofishing) is proportionally biased towards larger size-classes. Balanced population structure is observed following years when trend survey documented few young fish present in the population structure, thereby it can be assumed young, smaller fish were present but not sampled. Most juvenile sauger likely rear downstream of Intake Diversion (Penkal 1992) and autumn trend sampling reflects this. Proportionately low representation of smaller size-classes may result from proportionately low effort in rearing areas downstream of Intake Diversion. Most additional data were collected during early spring efforts to capture spawning sauger and are biased proportionally towards large fish. Drifted trammel nets, drifted gill nets and hook and line were the dominant gears deployed in spring. Size-specific relative weights are stable among years (Figure 5 B, D).

A) Autumn trend



B) Autumn trend



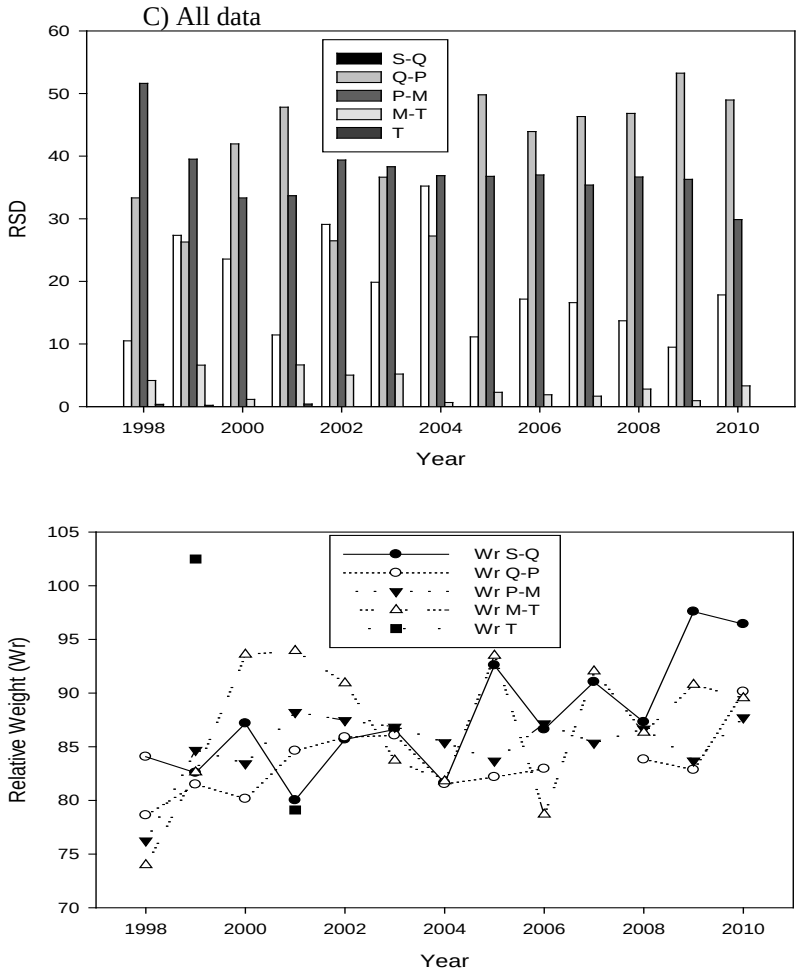


Figure 5. Incremental relative stock density (RSD) and relative weight (Wr) by length category of sauger captured in the Yellowstone River, 1998 to 2010

Sauger are a highly sought after species on the Yellowstone River and despite record high catch rates observed in 2008 and 2010 trend work, the population should continue to be closely monitored. Research concluding in 2004 documented that exploitation (18.6%) is unlikely to significantly affect this population during most years but is high enough that angler harvest should be monitored (Jaeger 2004).

Floy T-bar tags have been installed in sauger since 1997. Sauger were tagged during spring spawning aggregation. It was assumed that tagged fish randomly redistributed in the Yellowstone River, decreasing tag return bias. Since 2005, spring tagging efforts resulted in 2,728 tagged sauger. Of these, 185 were caught by anglers and 128 of these fish were harvested (Table 1)

Given that survival of adult fish is high (70.4%), increasing recruitment of juveniles to the adult population would further increase adult abundances barring compensatory responses (Jaeger 2004). Increasing recruitment of juveniles to the adult population can be best achieved by eliminating entrainment in Intake Canal.

Construction began in 2010 to install fish screens on the Intake head gates that will prevent entrainment of fishes at Intake Diversion. The head gate structure is anticipated to be completed and functional for the 2012 irrigation season. About 67,000 sauger, most of which are juveniles, are entrained in Intake Canal each year (Hiebert et al. 2000). This corresponds to a loss of over 13,000 five-fish angler limits annually. Completion of this project will prevent sauger entrainment but more importantly prevent entrainment of nearly 600,000 fish of 34 species during the mid-May to mid-September irrigation season.

Another threat to the sauger population is nonnative smallmouth bass. Expanding populations of nonnative smallmouth bass may adversely affect sauger abundances. Sauger abundances are significantly negatively correlated with smallmouth bass abundances ($P = 0.004$; Figure 6). Smallmouth bass have replaced sauger as the most common top predator in the Forsyth trend area. Smallmouth bass replaced sauger as the top predator in Miles City trend area until 2010 when above average flows returned (Figures 4 and 16). Smallmouth bass replaced sauger as the most common top predator in the Tongue and upper Missouri rivers following impoundment and resultant decrease in turbidity and alteration of natural hydrographs (McMahon and Gardner 2001). Loss of the natural hydrograph and warm, turbid prairie stream character of the Big Horn River combined with increasing prevalence of stream bank armoring of the Yellowstone River likely create conditions that favor smallmouth bass over sauger. Drought conditions until 2007 likely exacerbated these losses and observed increases in smallmouth bass abundances coincide with low flows.

Table 1. Annual tagging results for sauger in the Yellowstone River from 1997 to 2009. Returns refer to the number of fish harvested; returns in parentheses refer to the total number of fish caught.

Year tagged	Number tagged	Returns													
		1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
1997	38	0	0	1 (3)	0	0	0	0	0	0	0	0	0	0	0
1998	534		10 (32)	1 (17)	2 (2)	2 (3)	1 (1)	1 (1)	0	0	0	0	0	0	0
1999	465			7 (52)	5 (6)	1 (2)	2 (3)	1 (1)	1 (1)	0	0	0	0	0	0
2000	277				2 (6)	5 (9)	1 (5)	1 (3)	2 (2)	3 (3)	0	0	0	0	0
2001	338					14 (29)	18 (21)	4 (8)	4 (6)	1 (2)	0 (2)	0	0 (1)	0	0
2002	564						34 (44)	38 (44)	12 (13)	6 (6)	1 (3)	1 (1)	0 (1)	0	0
2003	338							21 (36)	13 (14)	2 (4)	1 (3)	0 (1)	1 (1)	0	0
2004	44								0	0	0	0	0	0	0
2005	432									4 (4)	3 (4)	3 (3)	11 (16)	0 (2)	1 (3)
2006	432										8 (8)	9 (10)	6 (9)	2 (3)	0
2007	691											16 (18)	8 (19)	8 (13)	5 (7)
2008	613												9 (16)	17 (20)	5 (7)
2009	560													8 (16)	5 (7)

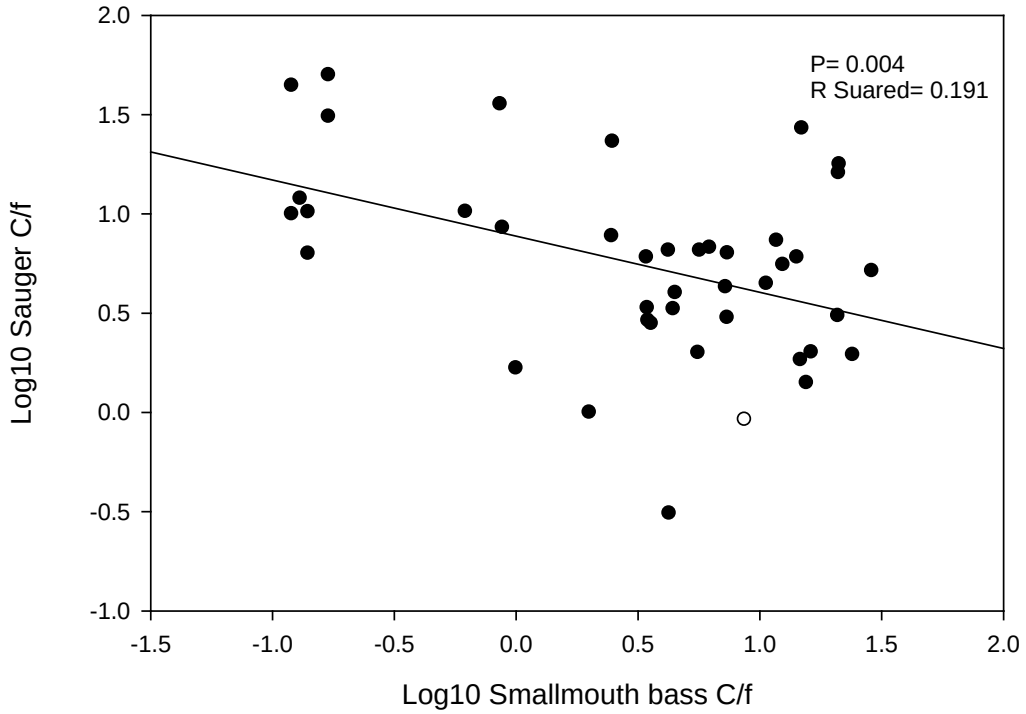


Figure 6. Relationship between sauger abundance and smallmouth bass abundance, Yellowstone River 1998 to 2010.

The expanding smallmouth bass population has the potential to outcompete and displace the native sauger in some reaches of its historic range. In 2005, stable isotope analysis was used to investigate potential interspecific competition between sauger and smallmouth bass in the Yellowstone River. Walleye are a similar nonnative species that coexists with sauger in the Yellowstone River and potential competition between sauger/walleye was also investigated.

Tissue samples for the isotope analysis were collected from 10 species in July 2005 near Rosebud Montana. Sauger and smallmouth bass (>200mm) overlap almost completely in both carbon and nitrogen, indicating that both of these species are consuming prey in similar proportions with the same carbon isotope signature (Figures 7 and 8). In addition nitrogen levels are very similar, indicating sauger and smallmouth bass (>200mm) are at the same trophic level. Walleye trophic position is higher than sauger. The higher walleye trophic position may be a result of the sampled walleye being of larger size, but this was not statistically analyzed. Walleye were also slightly more enriched in carbon than sauger, suggesting walleye are eating a slightly different combination of prey. Sauger, walleye, and smallmouth are all in relatively the same graph location suggesting interspecific competition is very probable. Note that the longnose sucker species mean with large confidence interval is probably lab error.

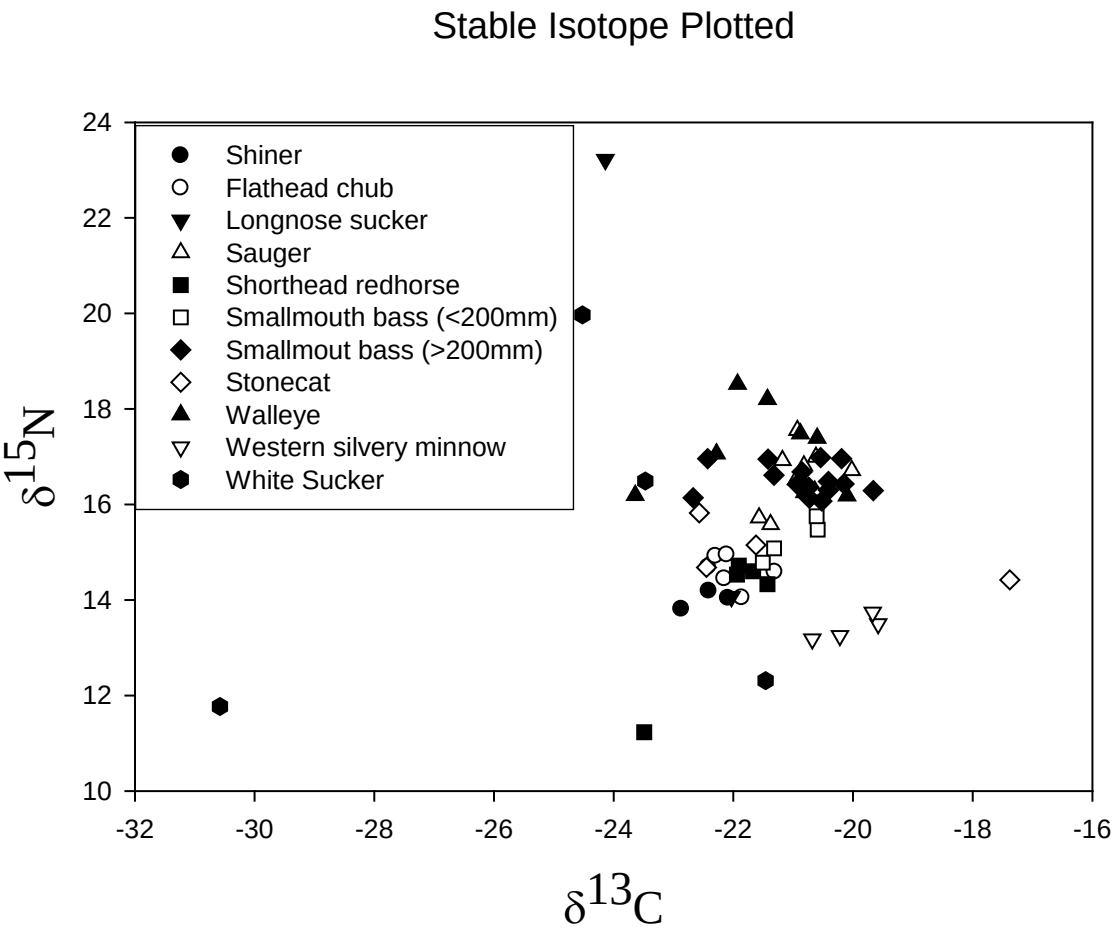


Figure 7. Stable carbon and nitrogen isotope signatures of fish collected from the Yellowstone River near Rosebud, Montana, July 2005.

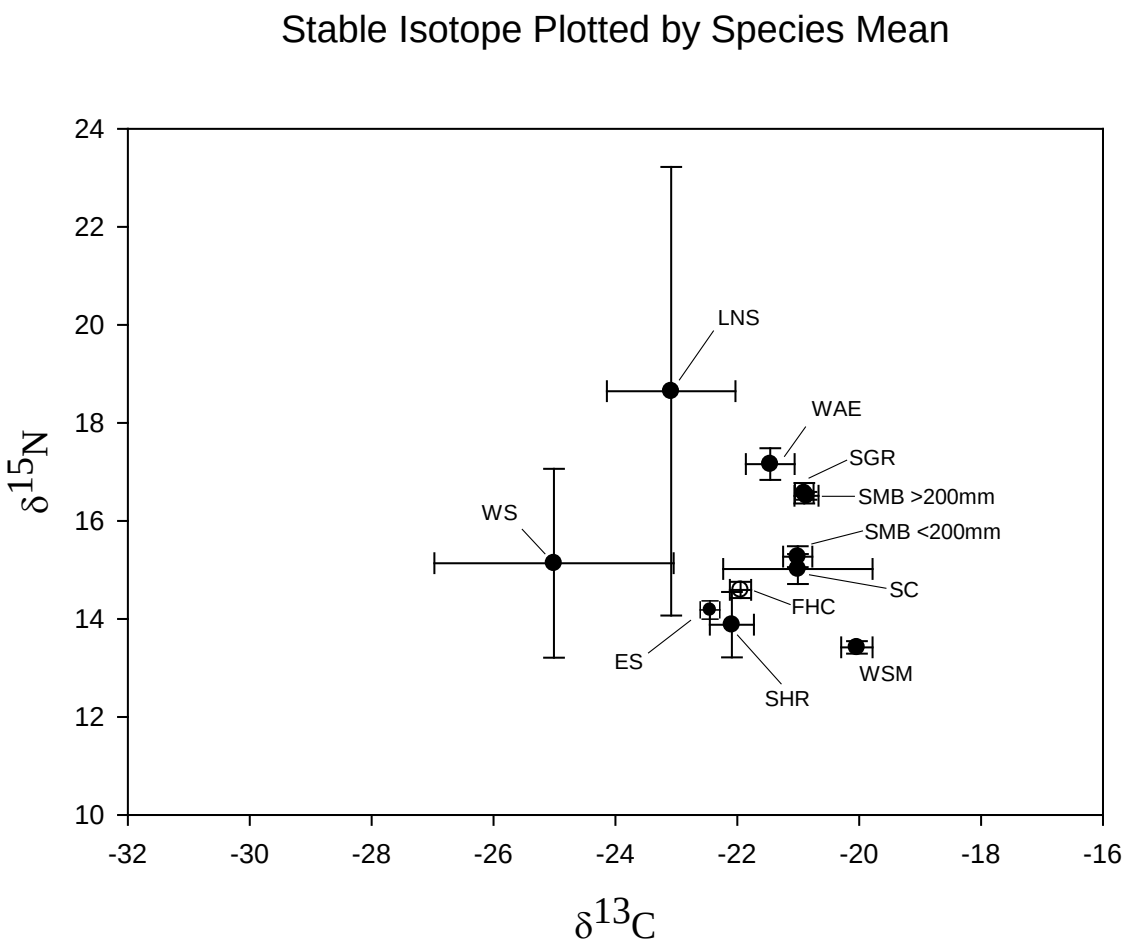


Figure 8. Stable carbon and nitrogen isotope signatures of fish collected from the Yellowstone River near Rosebud, Montana, July 2005. Species are walleye (WAE), sauger (SGR), smallmouth bass (SMB), stonecat (SC), longnose sucker (LNS), white sucker (WS), flathead chub (FHC), shorthead redhorse (SHR), emerald shiner (ES), and western silvery minnow (WSM). Error bars represent one standard error.

Population dynamics of sauger were further analyzed by investigating length age relationships of sauger. Aging structures were removed from sauger in 2002 to document length frequency and age distributions within the sauger population. Majority of sauger were sampled during spring tagging effort in April and May. The remainder of the aging structures were collected in August. There were 213 sauger-aging structures collected but only 180 collected samples sufficed for proper accurate age identification. Age 4 sauger were the most prolific in abundance, followed by age 2 sauger and then age 3 sauger (Figure 9). The oldest aged sauger was estimated 13 years of age and measured 520 mm. Age 1 sauger had a mean length of 223 mm, age 2 sauger had a mean length of 287 mm, age 3 sauger had a mean length of 342 mm, age 4 sauger had a mean length of 408 mm, and age 5 sauger had a mean length of 452 mm (Figure 10). Sauger sampled downstream of Intake Diversion Dam were younger and smaller than sauger sampled above intake diversion dam (Figure 11). Interpretation of sauger length frequency and abundance by age suggests the sauger population was stable in 2002.

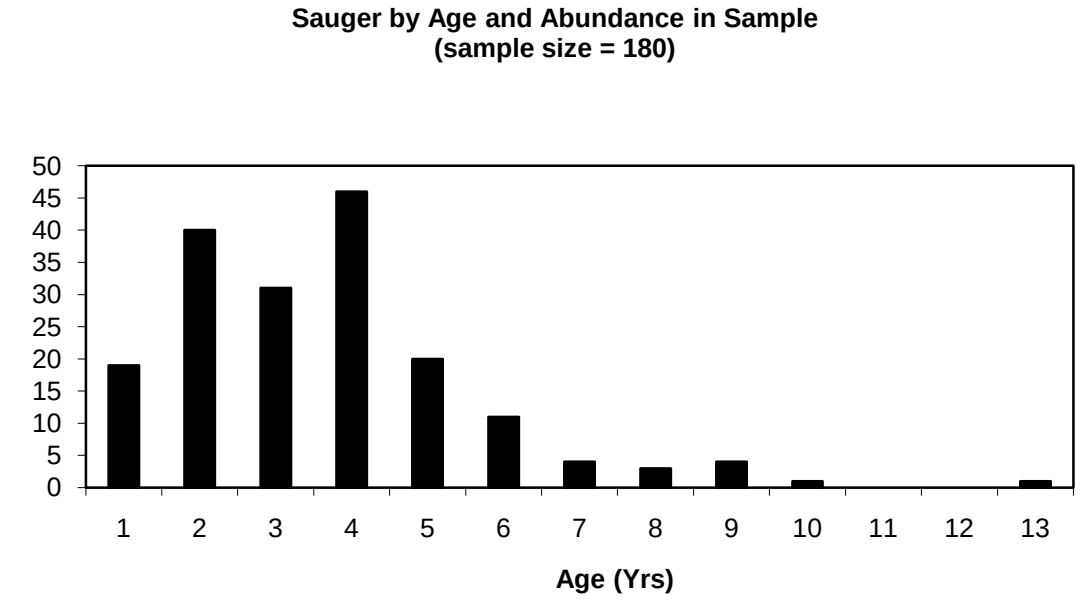


Figure 9. Sauger age and abundance collected from the Yellowstone River. Sample size was 180 fish.

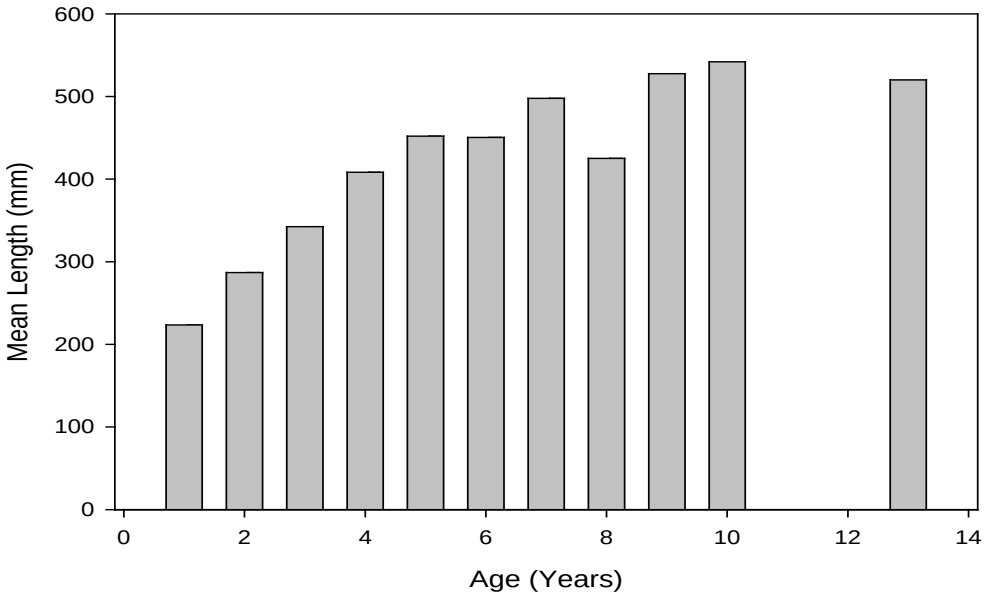


Figure 10. Sauger age in years and mean length collected from the Yellowstone River. Sample size was 180 fish.

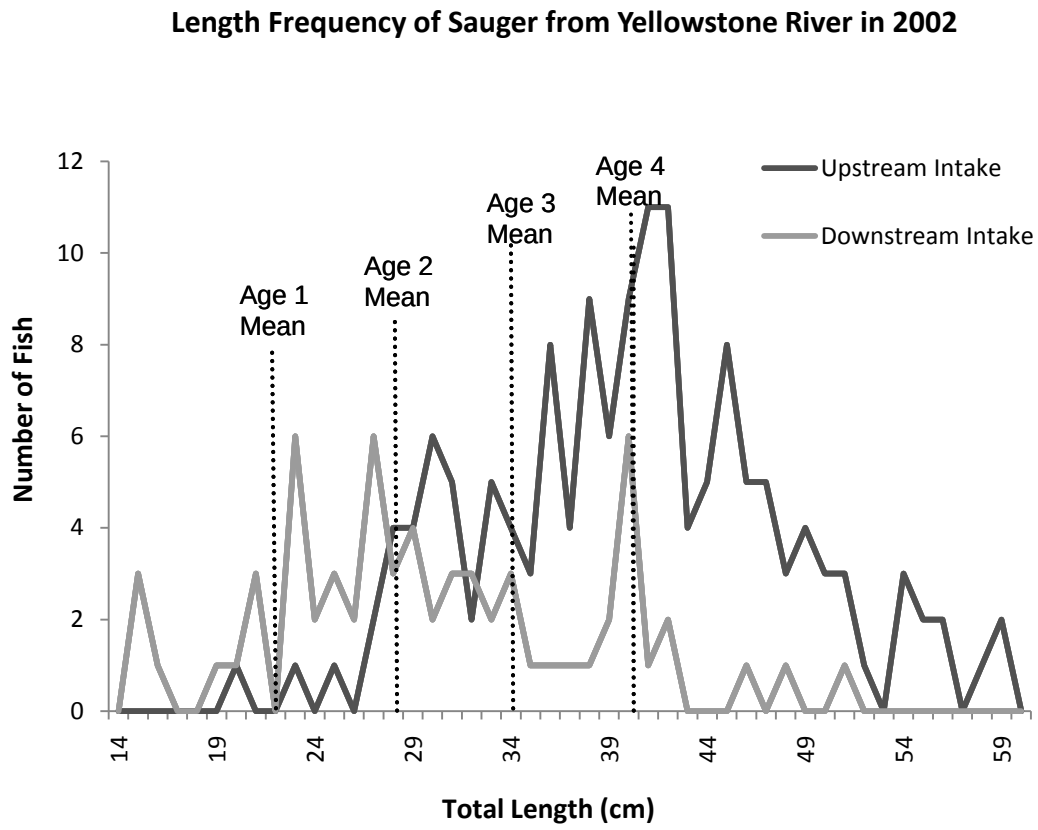


Figure 11. Length-frequency distribution of sauger collected from the Yellowstone River. Upstream and downstream of Intake diversion dam. Sauger mean age is represented with dashed vertical line.

Autumn trend surveys are extremely useful in making management decisions yet it is well recognized that sauger sampling efficiency varies in response to discharge, turbidity, conductivity, time of day, water temperature, substrate, water depth and other environmental factors. The magnitude of these effects on sampling efficiency is ambiguous and often disregarded. When sample sizes are small, a relatively small change in the number of fish captured suggests proportionately large changes in abundance. From 2005 to 2007 sauger were telemetered to study these implications. The report of this investigation is included as Appendix II.

Channel catfish

Channel catfish were the second most commonly sampled game fish. Overall catch rates increased (Figure 12). The average catch per hour has increased since 2008, as drought conditions experienced since 2000 have eased. Average catch rates in 2009 and 2010 were over 16 and 31 fish per hour respectively and are greater than any other year documented. Catch rates were similar among trend areas and were consistently highest in the Rancher and lowest in Intake trend areas (Figure 13).

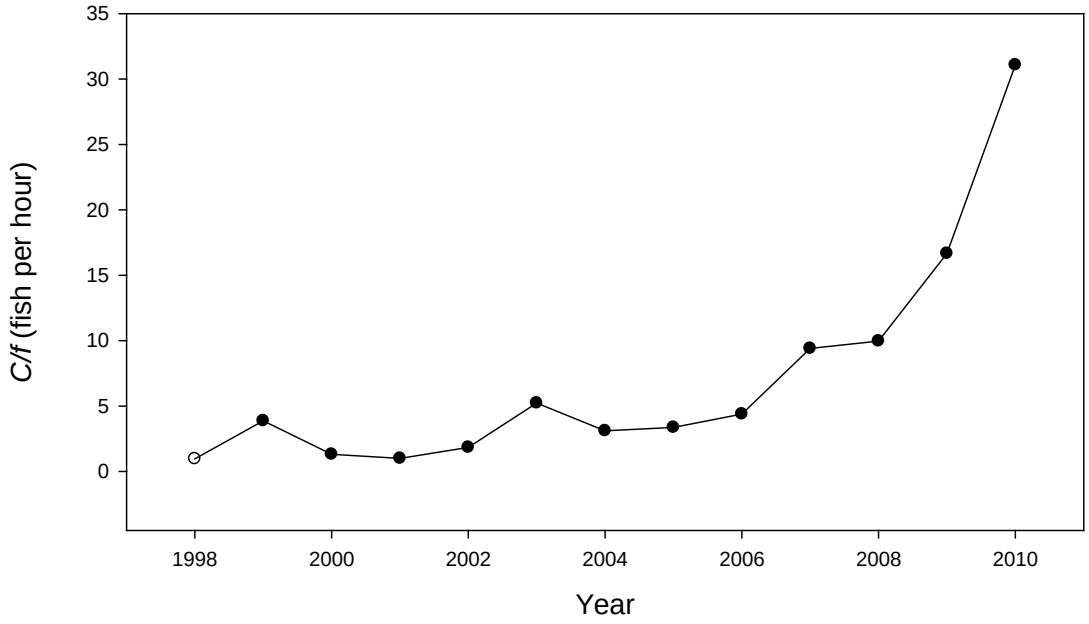


Figure 12. Catch per effort of channel catfish in the Yellowstone River, 1998 to 2010.

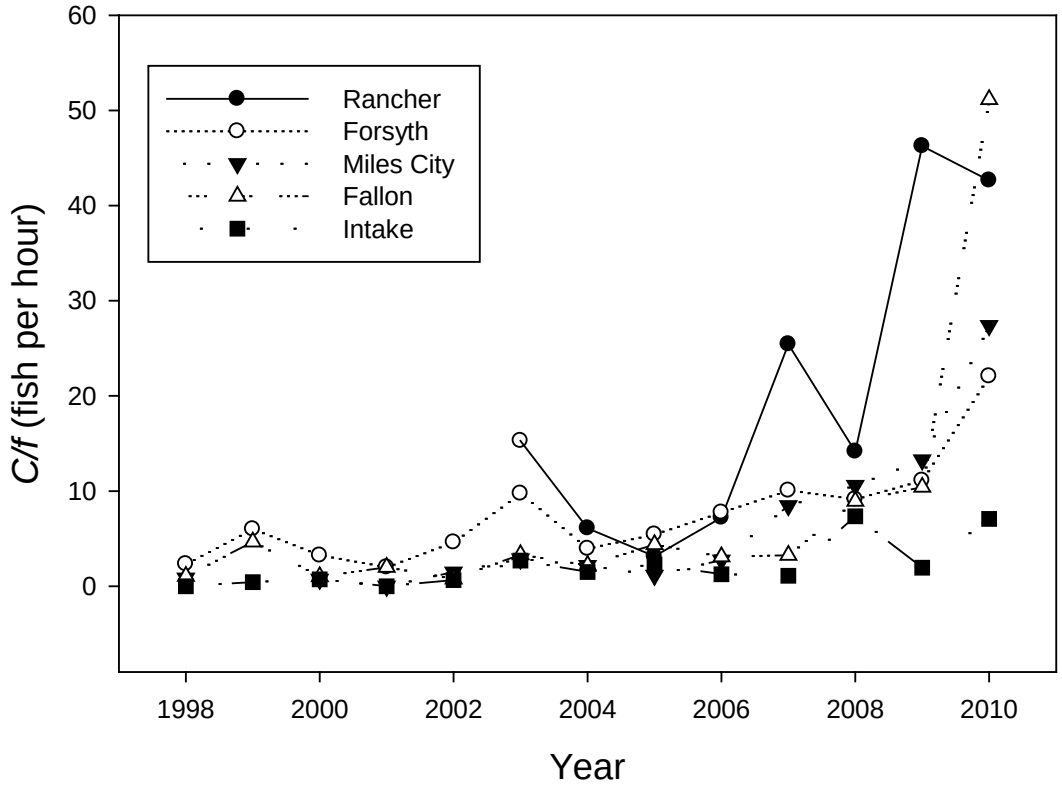
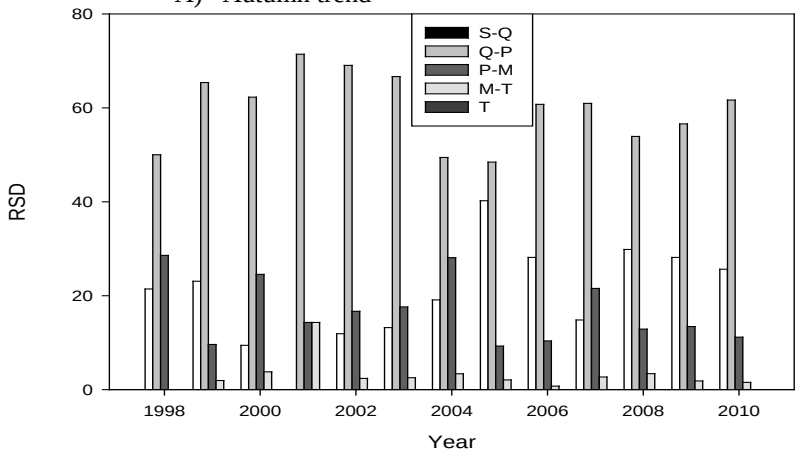


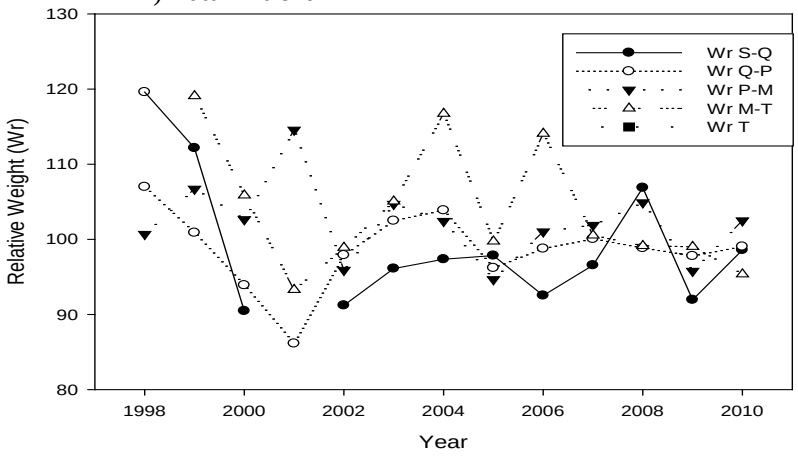
Figure 13. Catch per effort of channel catfish in the Yellowstone River by trend area, 1998 to 2010.

Condition of fish was relatively high during all years but has less fluctuation between size classes than previous years (Figure 14 B, D). Population structure remains very stable (Figure 14 A, C). Low proportions of stock to quality size fish suggests that smaller size classes had not fully recruited to the sampling gear (i.e. larger fish are more susceptible to electrofishing) or rear in un-sampled areas (i.e. deep pools, tributaries). Nonetheless, the stability of the observed population structure suggests that recruitment is not limiting. Fish were predominately quality to preferred size (410-610 mm) but about 11% were preferred to memorable (610-710 mm) and about 1% were memorable to trophy size (710-910 mm).

A) Autumn trend



B) Autumn trend



C) All data

D) All data

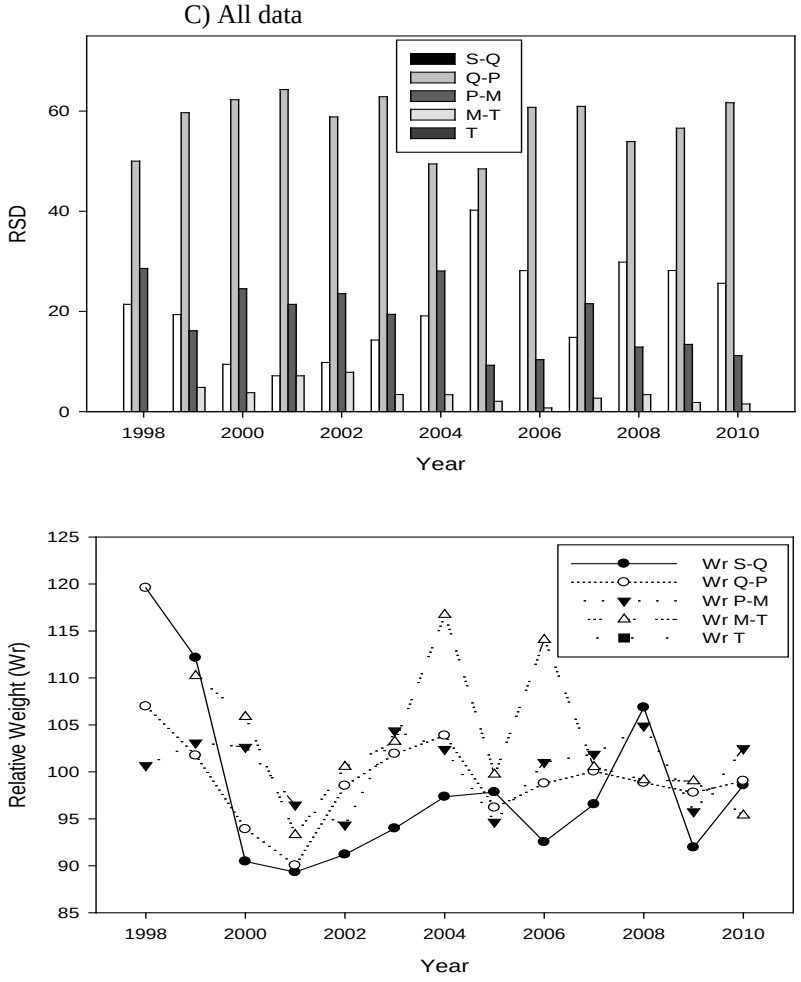


Figure 14. Incremental relative stock density (RSD) and relative weight (Wr) by length category of channel catfish captured in the Yellowstone River, 1998 to 2010.

Because of the relatively high abundances, large average size, and high length-specific weights of channel catfish, the Yellowstone River provides a unique and high quality fishery for this species, especially in upstream reaches. Few fish greater than the preferred to memorable size category is noteworthy and should be monitored in future trend surveys.

Smallmouth bass

Smallmouth bass catch rates increased drastically from 1.5 fish per hour in 1998 to 8.8 fish per hour in 2010 (Figure 15). Catch rates in 2008 were at an all time high of 13.6 fish per hour. Increased abundance coincided with the onset of drought conditions that likely favored smallmouth bass. Since the return of above average flows, smallmouth bass catch rates have trended downward. Smallmouth bass were the third most frequently encountered game species overall despite only being commonly observed in the trend sections upstream of Miles City (Figure 16). Population structure was balanced but appears to be skewed towards smaller size classes (Figure 17 A, C). Majority of fish are in the stock to quality length category. Condition of smallmouth bass in the Yellowstone River was high for all size-classes (Figure 17 B, D).

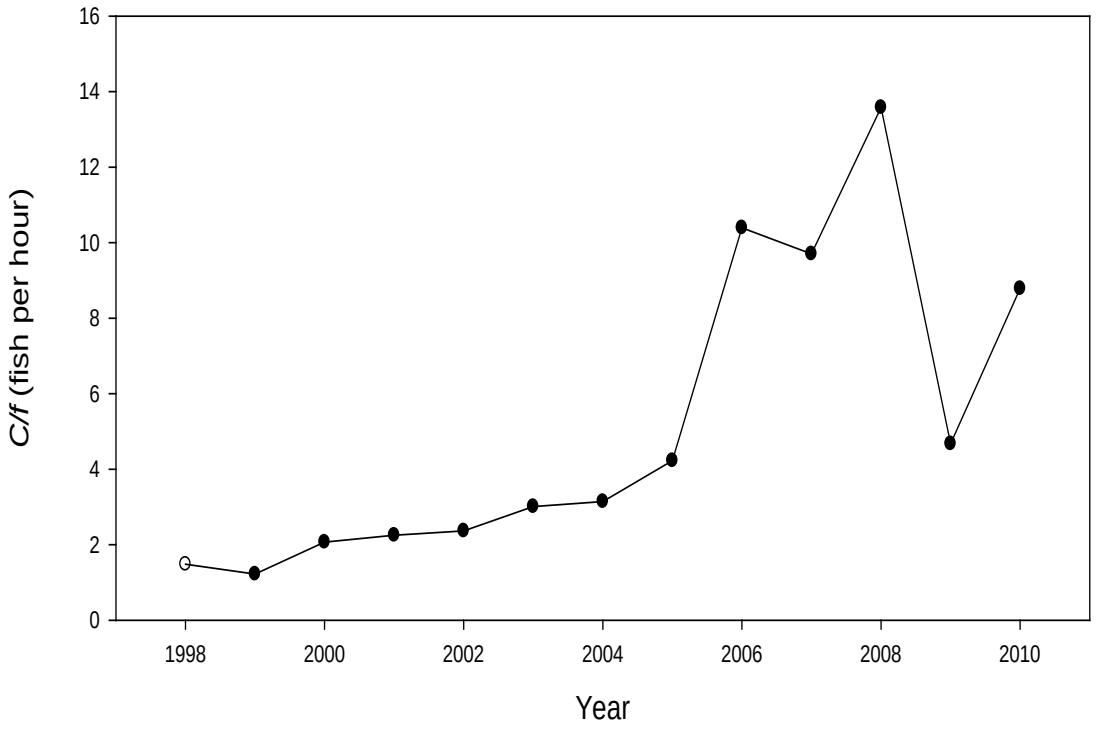


Figure 15. Catch per effort of smallmouth bass in the Yellowstone River, 1998 to 2010.

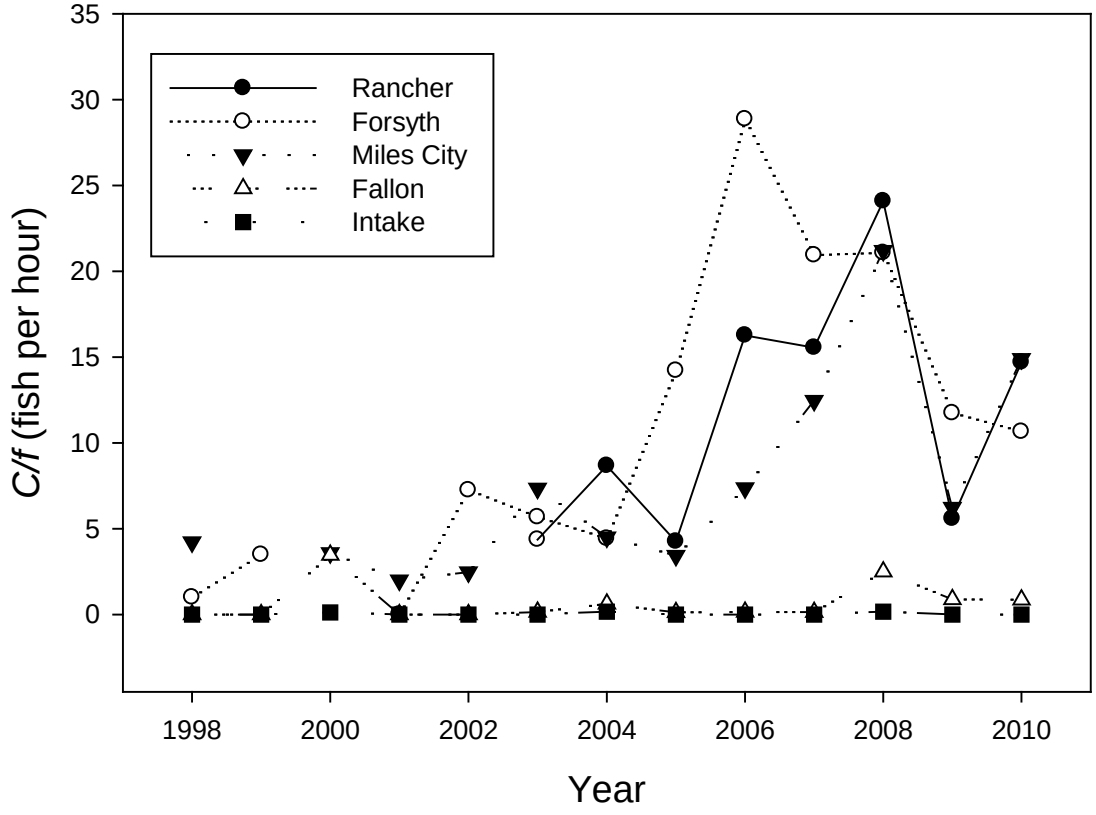
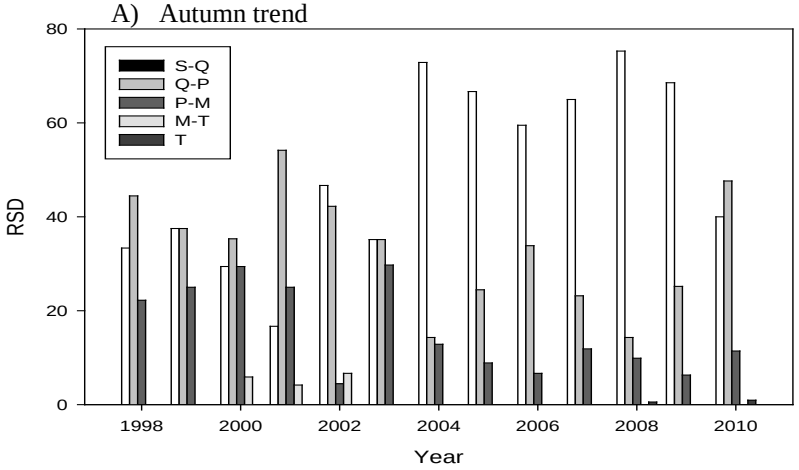


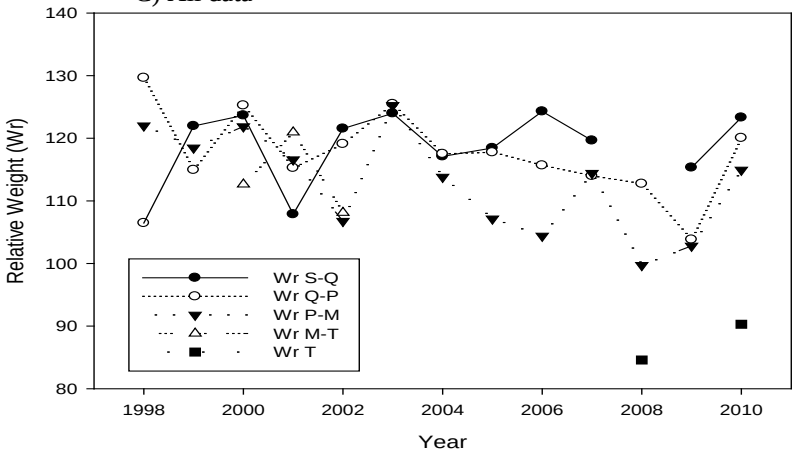
Figure 16. Catch per effort of smallmouth bass in the Yellowstone River by trend area, 1998 to 2010.

A) Autumn trend



B) Autumn trend

C) All data



D) All data

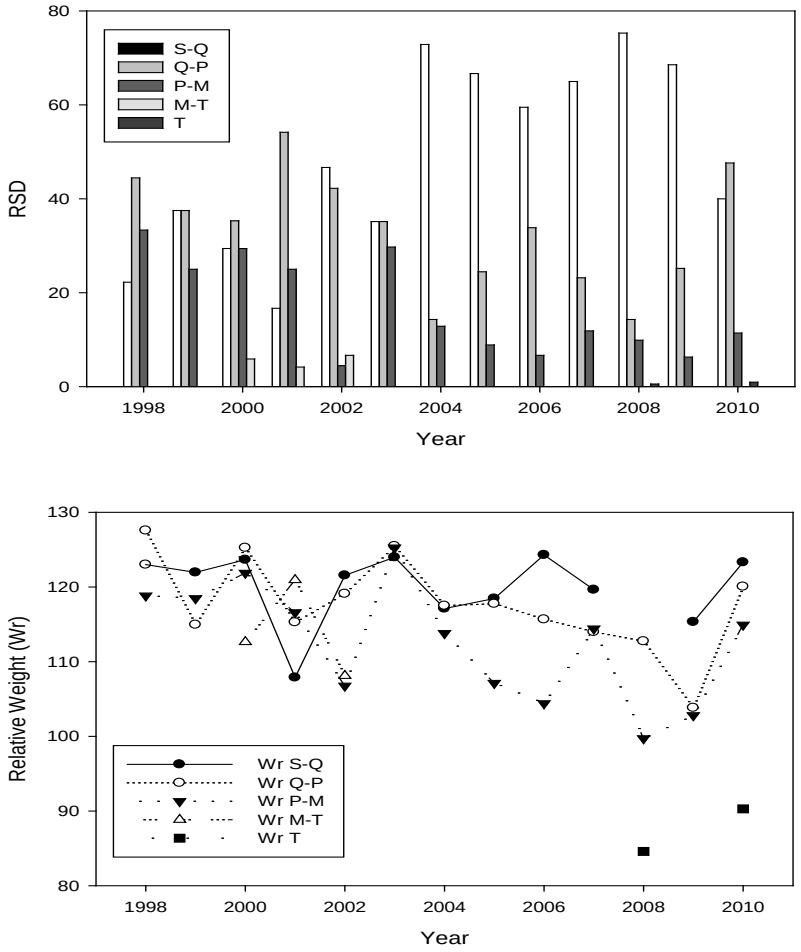


Figure 17. Incremental relative stock density (RSD) and relative weight (Wr) by length category of smallmouth bass captured in the Yellowstone River, 1998 to 2010.

Increasing abundances and considerable length-specific weight of smallmouth bass in the Yellowstone River provide an excellent angling opportunity upstream of Miles City. However, populations of native fishes, specifically sauger, should continue to be closely monitored, as nonnative smallmouth bass expand in range and abundance.

Shovelnose sturgeon

Shovelnose sturgeon abundances during autumn trend surveys has increased during the study period (Figure 18); however, limited inferences can be drawn from these data as electrofishing is a relatively inefficient sampling method for this species. Trend sampling using more efficient gears, such as drifting trammel nets (e.g. Backes and Gardner 1994), would allow more robust estimates of population trends. Nonetheless, current trend sampling and incidental netting efforts suggest that shovelnose sturgeon are abundant and widespread downstream of Cartersville Diversion.

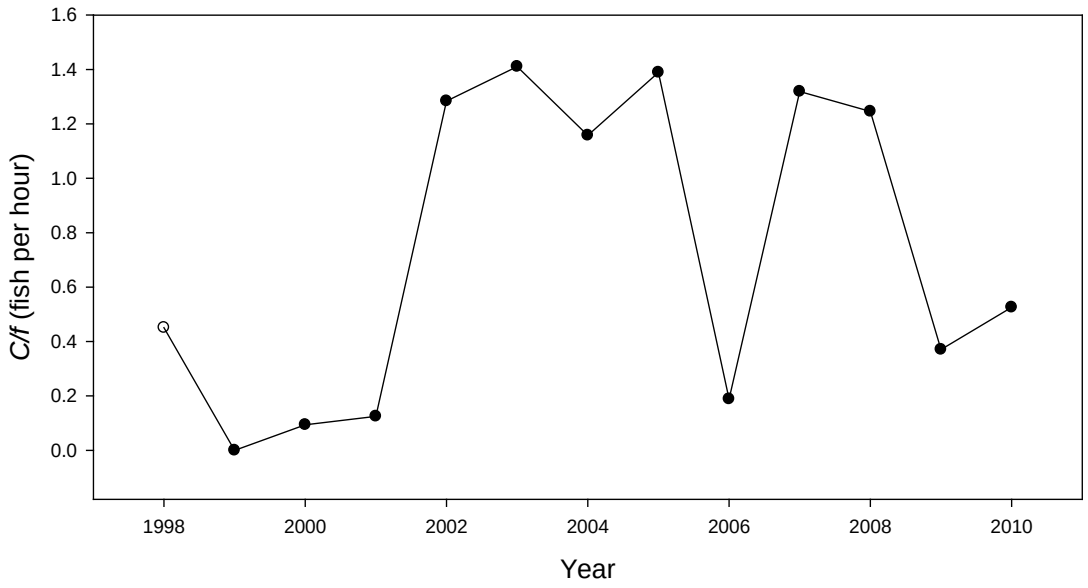


Figure 18. Autumn trend survey catch per effort of shovelnose sturgeon in the Yellowstone River during autumn trend survey, 1998 to 2010.

Shovelnose sturgeon sample size increased radically in 2009 and 2010 by enumerating all by-catch of shovelnose sturgeon captured during the August pallid sturgeon survival analysis. The first 25 shovelnose sturgeon captured daily during the survival analysis are measured and weighed. One-inch trammel nets drifted during the survival analysis captured 1,563 and 1,326 shovelnose sturgeon during 2009 and 2010 collections respectively. Catch rates per hour and catch rates per river km both decreased in 2010 from 2009 rates (Figure 19). Future catch rates may provide useful data for future population dynamic investigations.

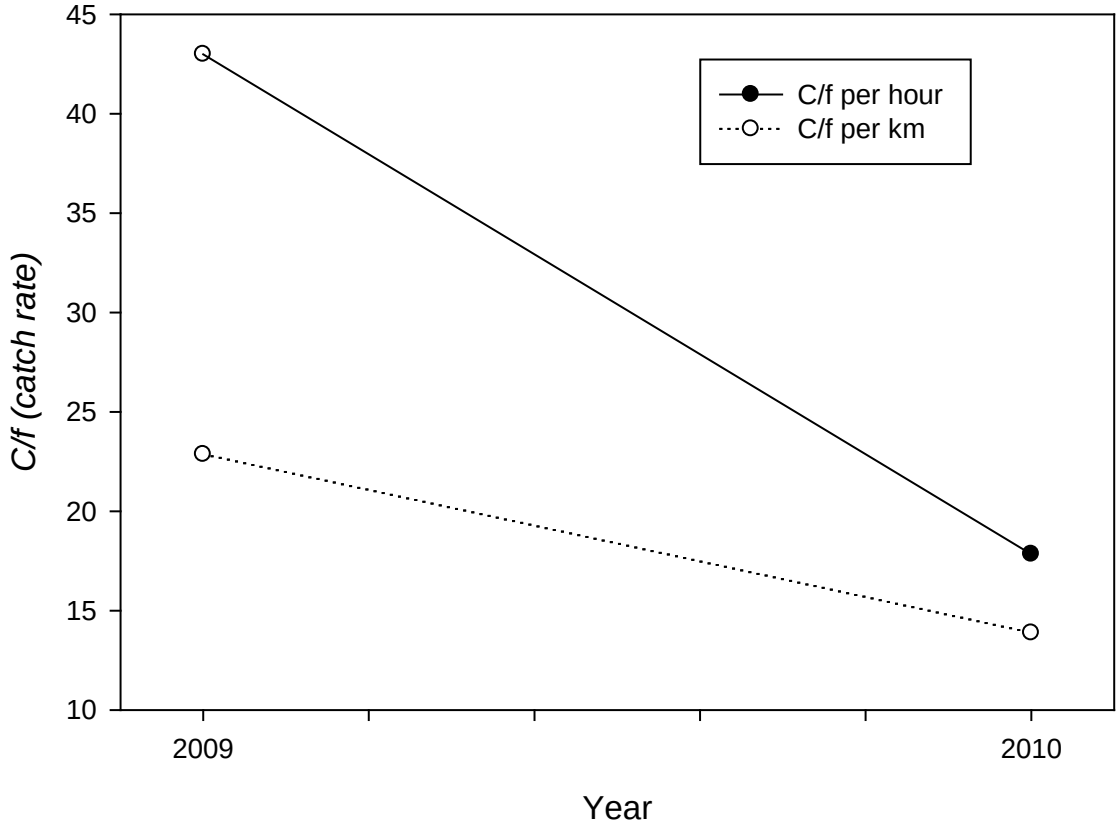


Figure 19. Catch rates of shovelnose sturgeon in the Yellowstone River in 2009 and 2010 during the August survival analysis.

Highly variable catch rates during trend sampling resulted in limited population structure and condition information (Figure 20 A, B). However, combining all available data for each year suggested that population structure is stable and balanced (Figure 20 C). Size-specific condition was stable among years and stabilized further in recent years likely in response to increased sample size from pallid sturgeon survival analysis collections (Figure 20 D).

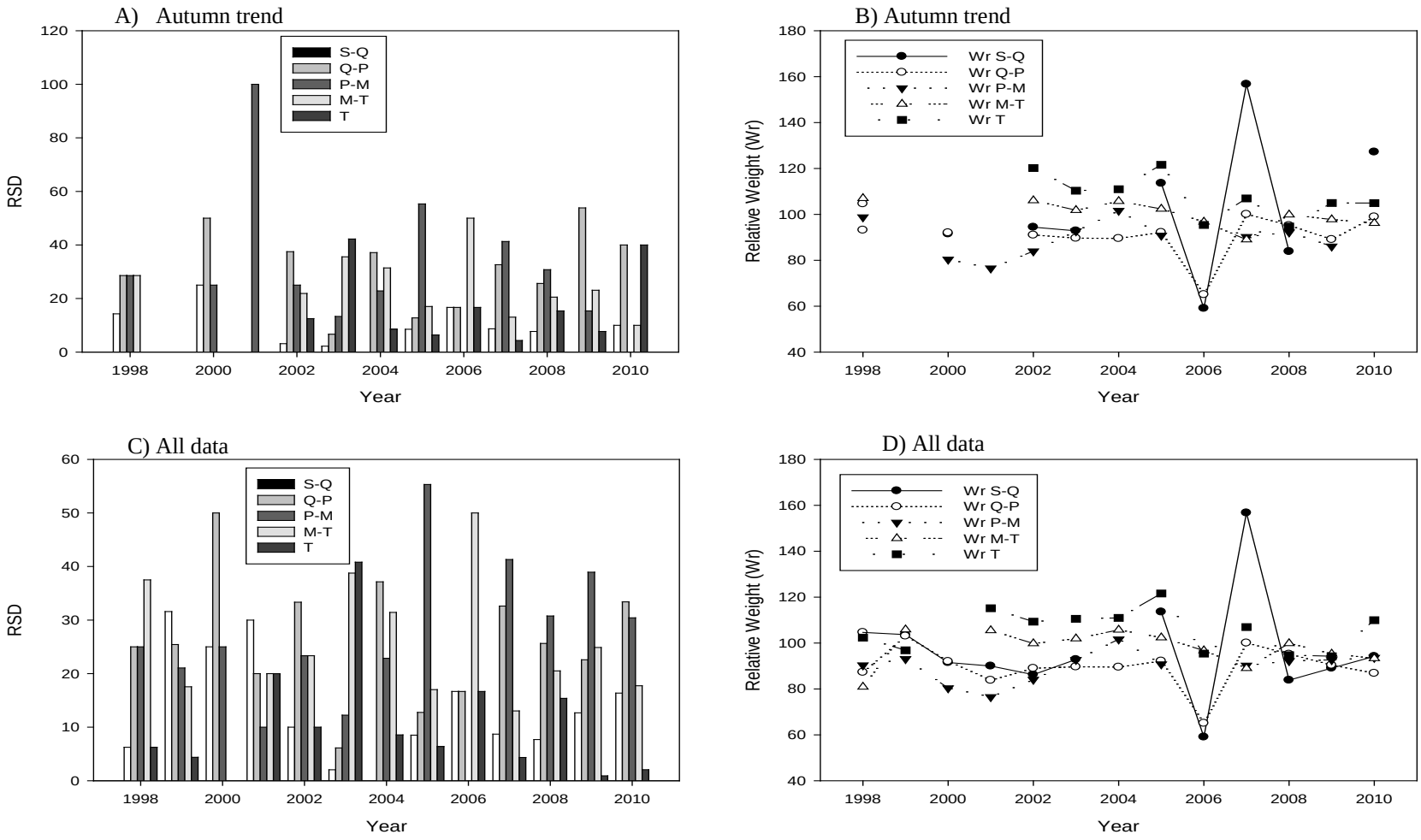


Figure 20. Incremental relative stock density (RSD) and relative weight (Wr) by length category of shovelnose sturgeon captured in the Yellowstone River, 1998 to 2010.

Burbot

Burbot catch rates were consistently low (Figure 21). Low catch rates were likely related to the timing and gear used for sampling; burbot are most effectively sampled with baited hoop nets in the early spring and late autumn (Jones-Wuellner and Guy 2004). However, it is also possible that burbot are limited by the relatively high summer temperatures of the lower Yellowstone River (e.g. Nikcevic et al. 2000) and the low catch rates observed accurately reflect low abundances. Electrofishing is an inefficient method for capturing burbot thereby, these autumn trend data likely only provide an indication of presence or absence.

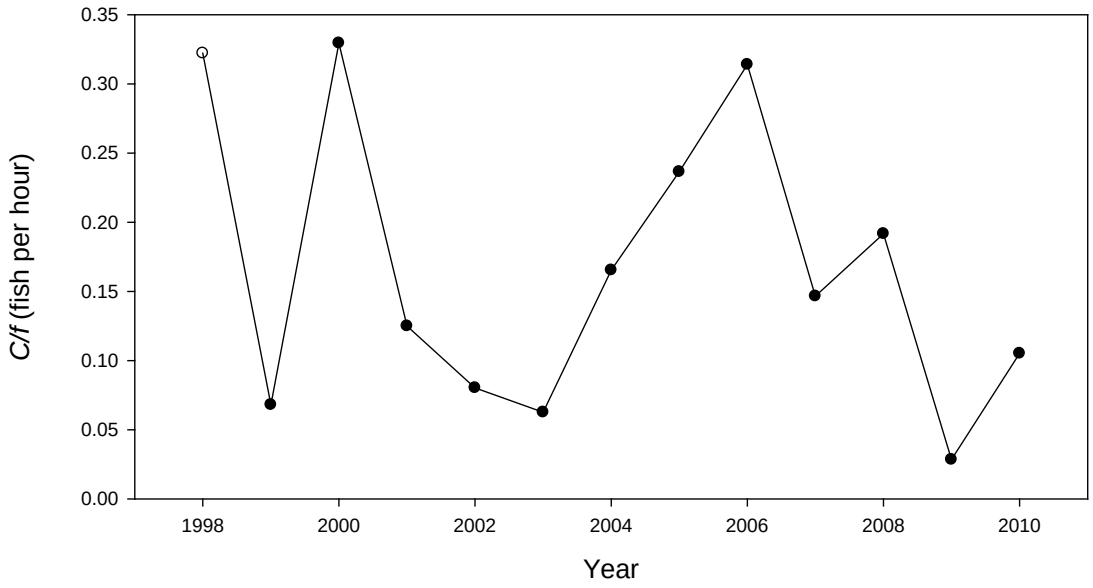
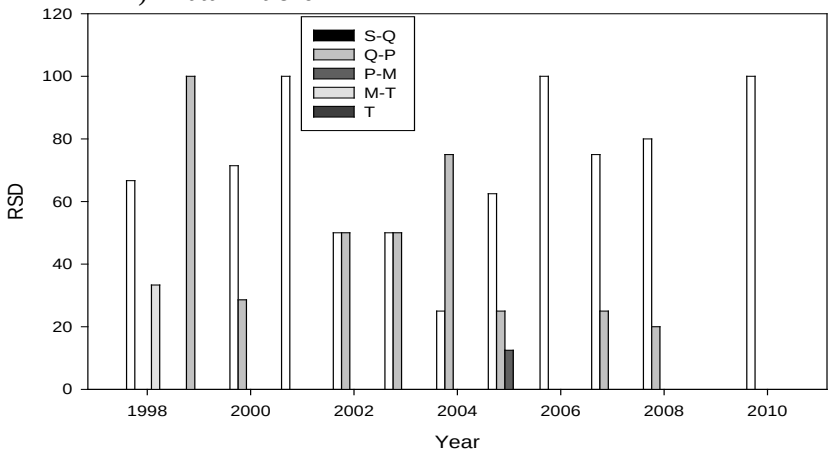
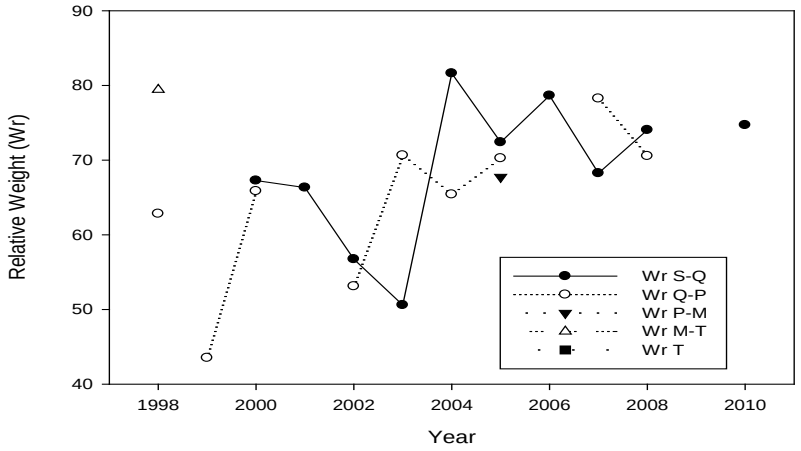


Figure 21. Autumn trend survey catch per effort of burbot in the Yellowstone River, 1998 to 2010.

Low catch rates also limit inferences related to population structure and condition. Most burbot sampled during the autumn trend surveys were relatively small and of poor condition (Figure 22 A, B). Despite the addition of all length and weight data the number of burbot sampled was low and limited inferences related to this data set (Figure 22 C, D). Different gear types and sampling times would be necessary to obtain an adequate sample size to characterize abundances, structure, and condition of this population.

A) Autumn trend





B) All data

C) Autumn trend

D) All data

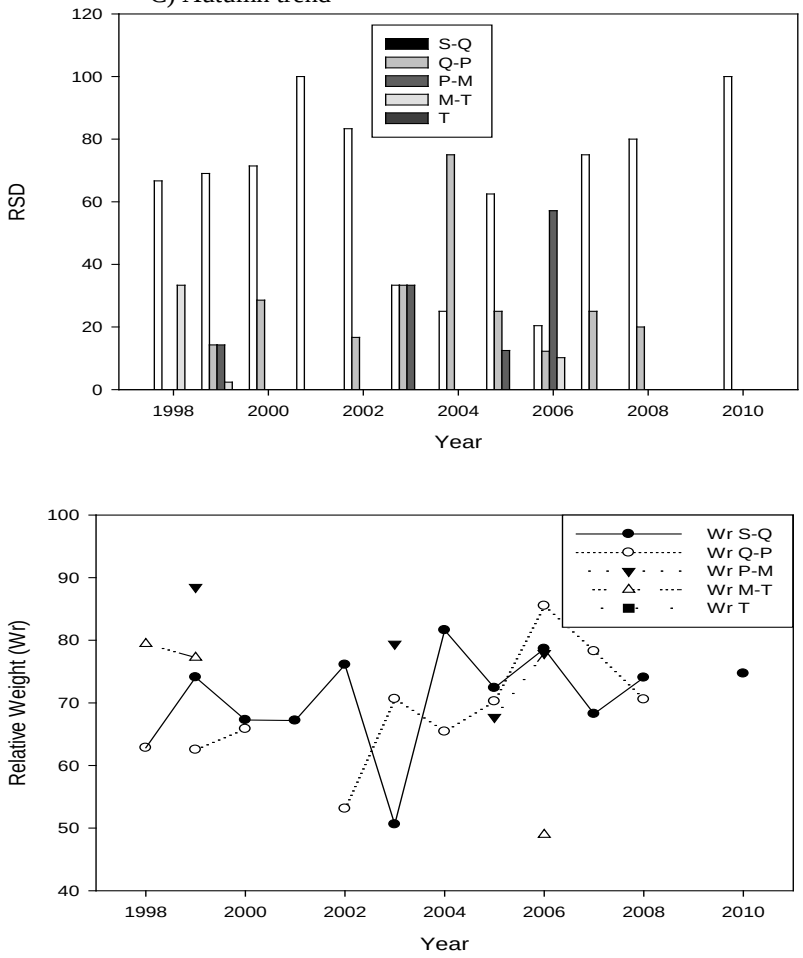


Figure 22. Incremental relative stock density (RSD) and relative weight (Wr) by length category of burbot captured in the Yellowstone River, 1998 to 2010.

In 2004 and 2005 research was conducted investigating the presence and distribution of burbot in the Yellowstone River. Burbot were captured with baited hoop nets set for 24-72 hours. Burbot catch rates increased as river km increased (Figure 23). Catch rate was again investigated in 2006, 2007 and 2008. Experimental design and sample locations did not allow direct comparison of catch rates by year but provided indication of presence or absence. Burbot were caught in all years sampled and catch rates were variable (Figure 24). Length and weight measurements were not included in research methods so no additional length weight data was gained for all data comparison. Because of poor catch rates and limited knowledge gained from these efforts intense burbot sampling will be conducted every 4 years beginning in 2012. Future efforts will use methods to allow for population trend and size structure comparisons by collection years.

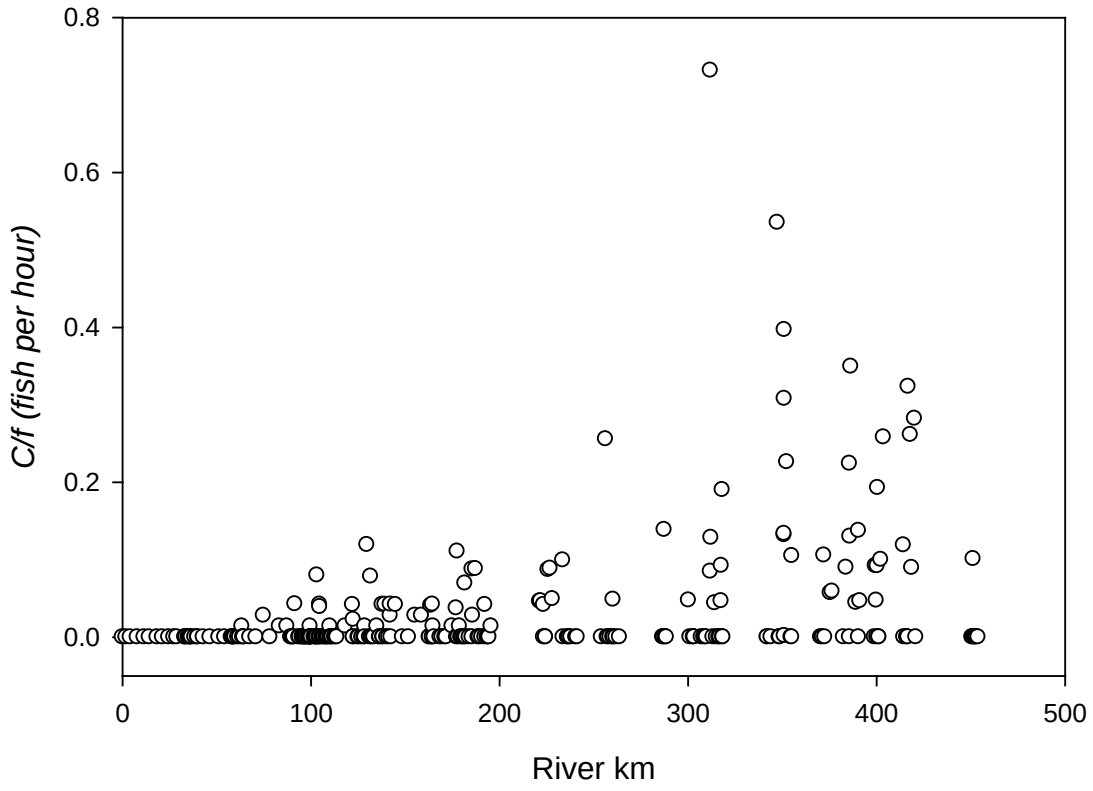


Figure 23. Catch per effort of burbot plotted per river km in the Yellowstone River from 2004-2005.

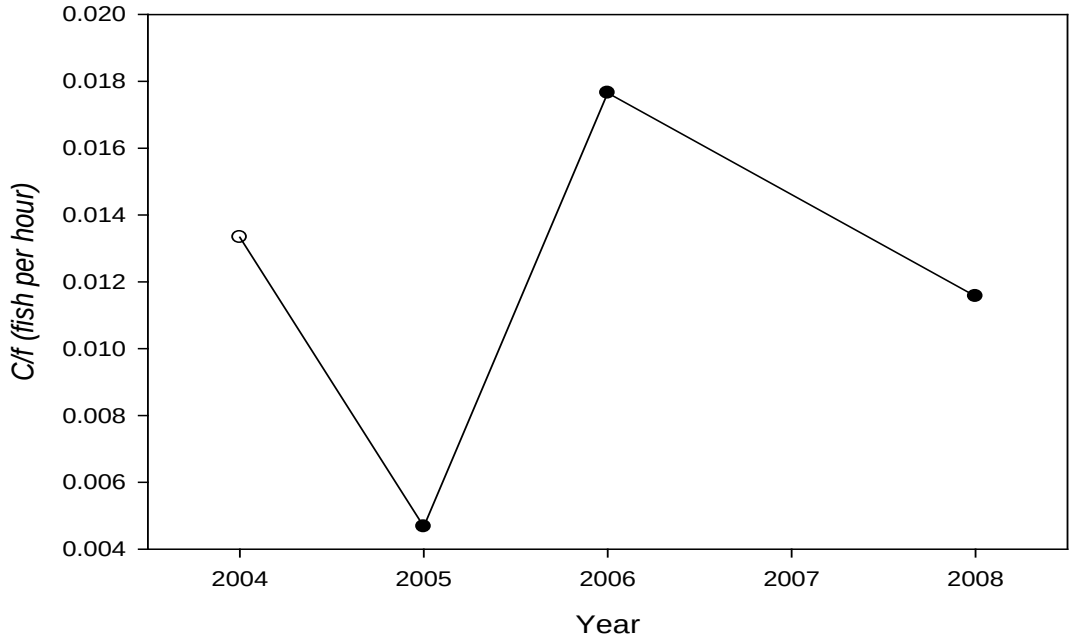


Figure 24. Catch per effort of burbot using baited hoop nets in the Yellowstone River in 2004-2006 and 2008.

Walleye

Catch rates of walleye were consistently low from 1998 to 2007 and then trend upward since 2008 (Figure 25). Most walleye in the Yellowstone River were thought to be part of an adfluvial population residing in Sakakawea Reservoir (Penkal 1992). Adults move into the Yellowstone from late autumn to early spring, spawn during April, and return to the reservoir (Penkal 1992). In recent years, Sakakawea Reservoir water level has been elevated and the headwaters have been in closer than normal proximity to the Yellowstone River confluence. It is probable that the increased proximity to Sakakawea Reservoir headwaters may have influenced the upward trend of walleye in autumn trend surveys. This upward trend should be monitored closely and is of concern because of sauger/walleye hybridization potential and increased competition with native sauger as described in the stable isotope investigation.

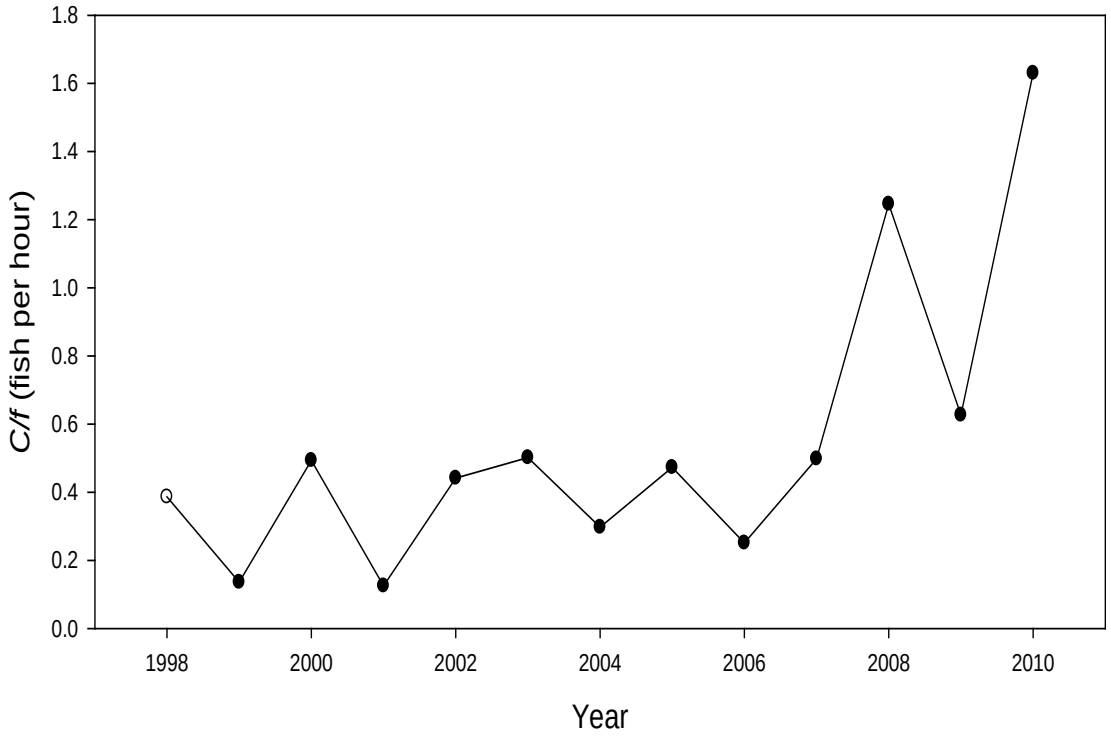


Figure 25. Catch per effort of walleye in the Yellowstone River, 1998 to 20010.

The walleye population structure was unbalanced and skewed towards smaller fish when trend surveys began but in recent years the population has shifted towards larger fish (Figure 26 A, C). Size-specific condition of small walleye is less than sauger of the same size but as walleye increase in length their size-specific condition is greater than that observed for sauger of the same size (Figure 26 B, D).

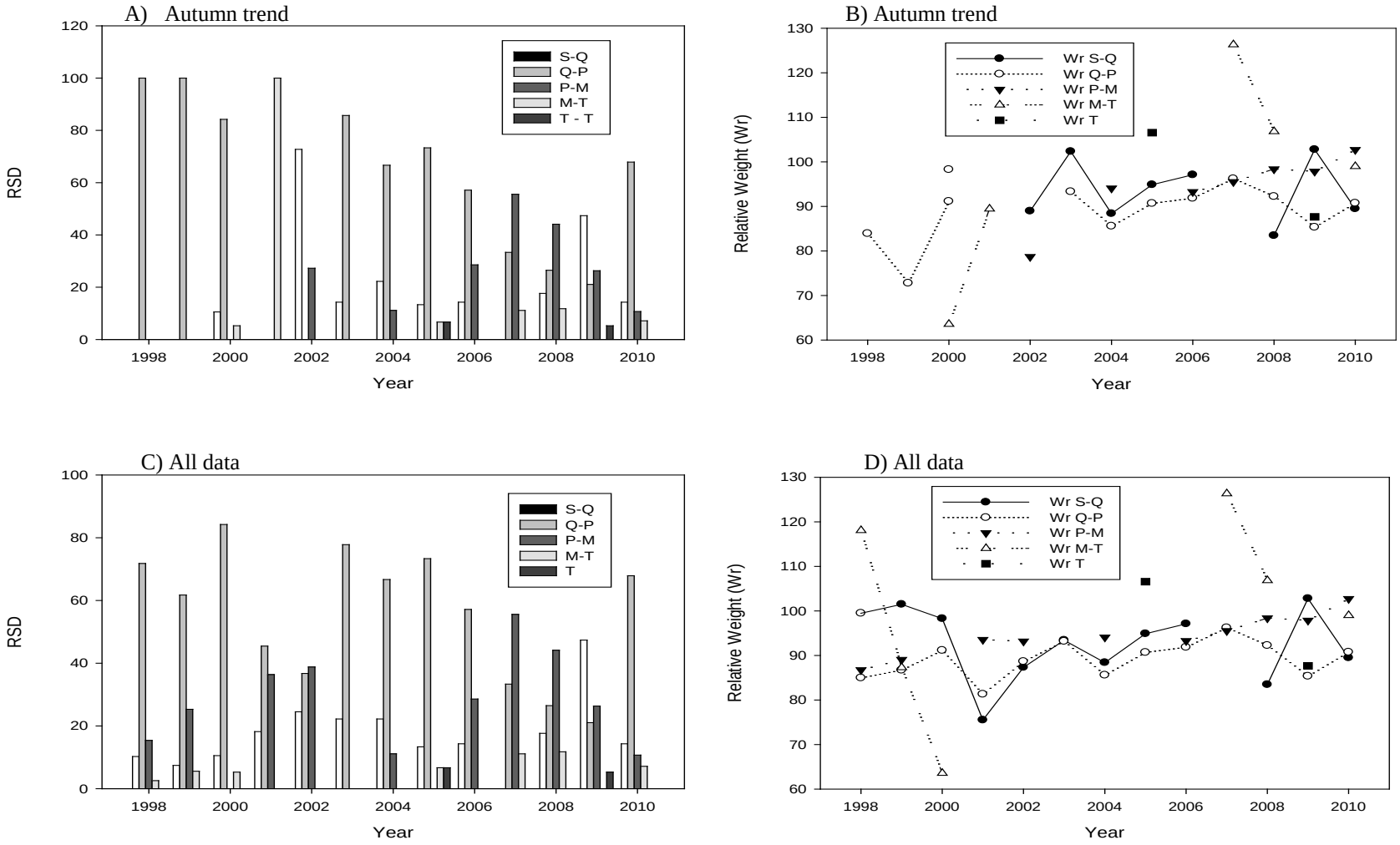


Figure 26. Incremental relative stock density (RSD) and relative weight (Wr) by length category of walleye captured in the Yellowstone River, 1998 to 2010.

Rare game fishes

Abundances of most rarely encountered game fish were low during years of low flow and increased in times with above average flows (Figure 27). Brown trout were first captured in 2008 and in 2010 and were the most abundant rare game fish captured these years. All of these fishes are nonnative and more commonly associated with cold water or lentic habitats.

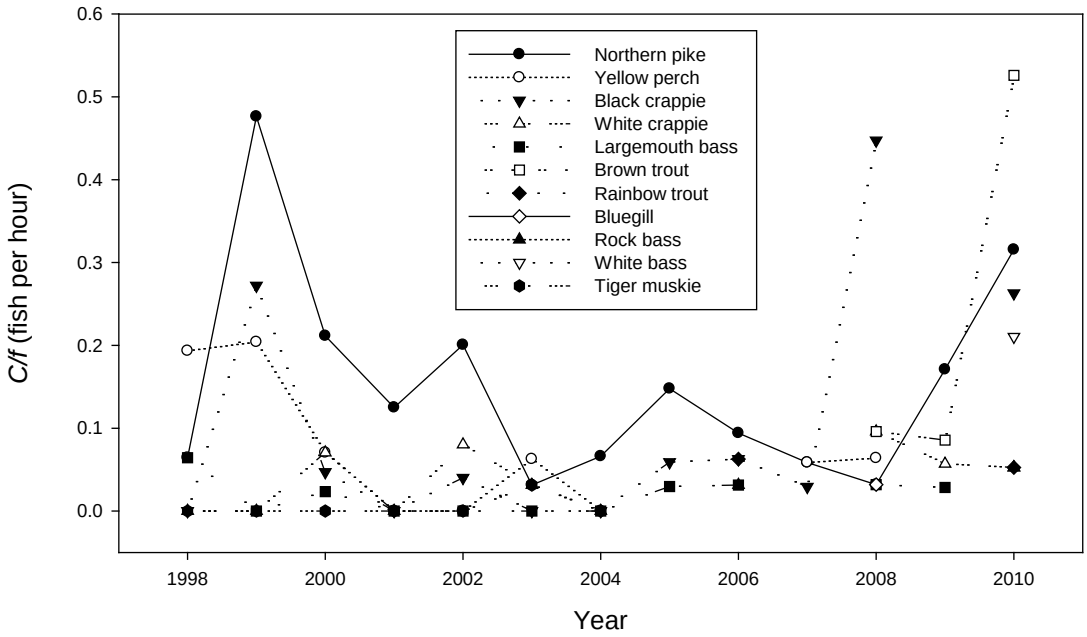


Figure 27. Catch per effort of rare game fishes in the Yellowstone River, 1998 to 2010.

Common non-game fishes

All abundances of common non-game fishes increased in 2010 and were at levels higher than existed in recent years (Figure 28). Shorthead redhorse sucker, and river carpsucker were the two most abundant species. Increased water levels were favorable for common non-game fishes.

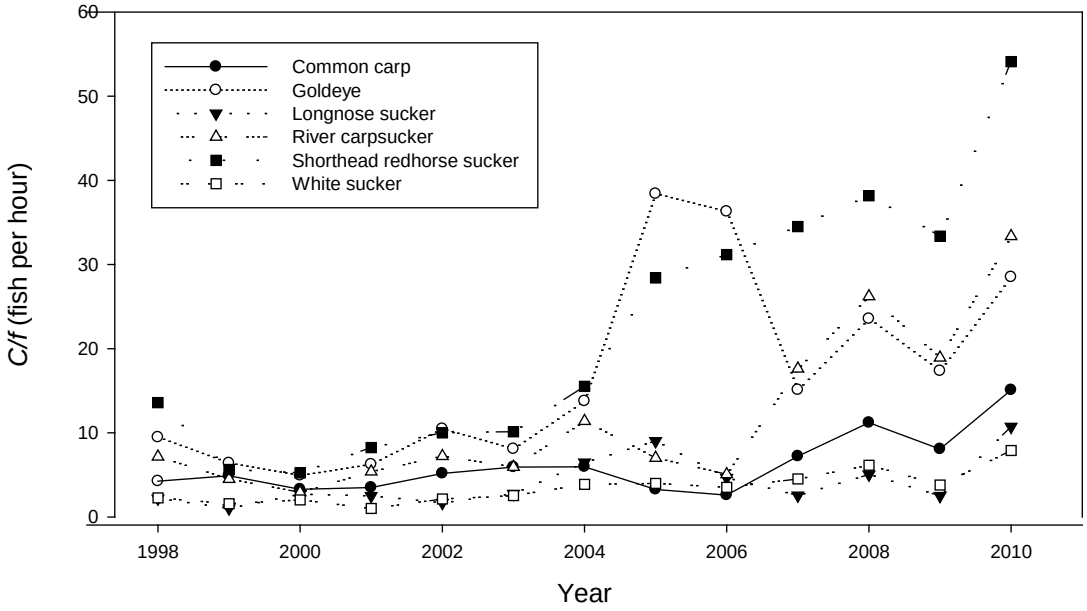


Figure 28. Catch per effort of common non-game fishes in the Yellowstone River, 1998 to 2010.

Rare non-game fishes

Abundance of rare non-game fishes were consistent or increased during the study period (Figure 29). Abundances of blue sucker, a Species of Special Concern, exhibited proportionally large fluctuations from 1998 to 2000 and displayed a slight decline in 2010 but were stable overall. Freshwater drum were the most abundant rare non-game fish captured. Abundance of freshwater drum catch per effort was below 1 fish per hour until 2008. During the 2010 trend survey, freshwater drum were documented at an all time high abundance of 3.4 fish per hour. Smallmouth buffalo were the second most abundant rare non-game fish.

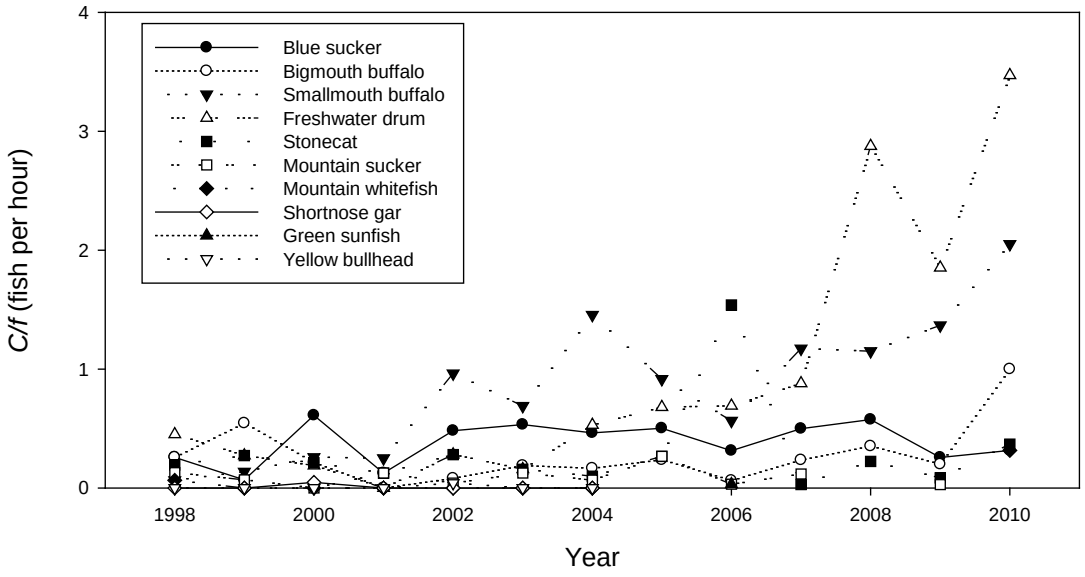


Figure 29. Catch per effort of rare non-game fishes in the Yellowstone River, 1998 to 2010.

Cyprinids

Only three cyprinids (flathead chub, Hybognathus spp., emerald shiner) were commonly encountered and catch rates of these species exhibited proportionally large fluctuations but a general upward trend since 2004 (Figure 30). Although electrofishing is an inefficient sampling method for most cyprinids, seine surveys found similar relative abundances among species in the Yellowstone River (Stewart 1997). Sturgeon chub, a Species of Special Concern, were rarely captured. However, electrofishing is an inefficient sampling method for this species (Stewart 1996). Sturgeon chub were commonly captured with benthic trawls throughout the Yellowstone River downstream of Cartersville Diversion (Bill Gardner, Montana Fish, Wildlife, and Parks, Lewistown, Montana, personal communication).

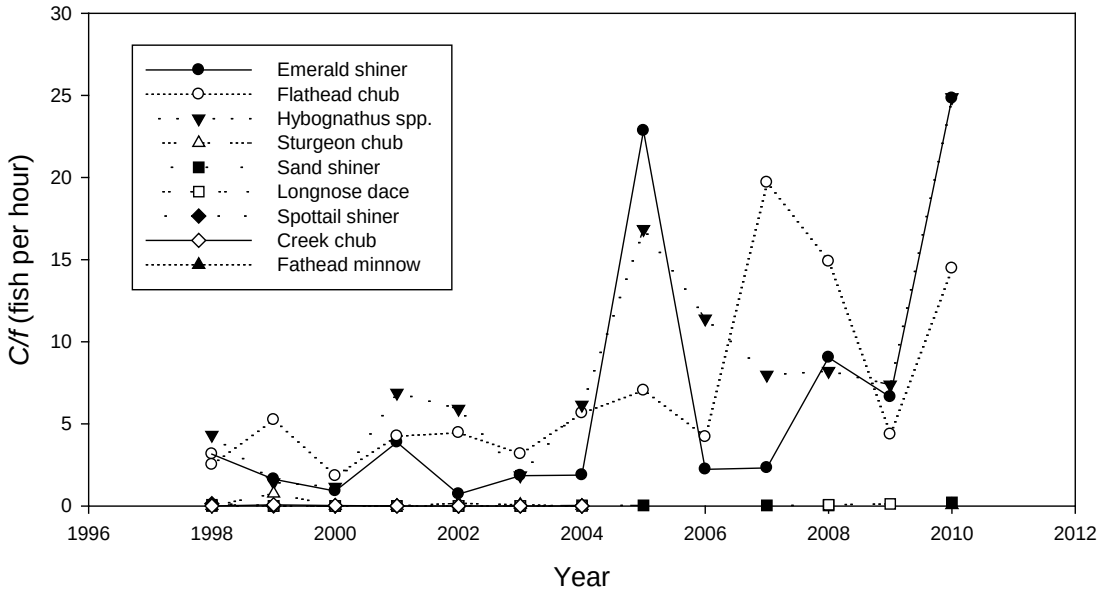


Figure 30. Catch per effort of cyprinids in the Yellowstone River, 1998 to 2010.

Spiny soft-shell turtles

The Yellowstone River riparian corridor supports a diverse wildlife assemblage, including spiny soft-shell turtles that are labeled a tier I species of Greatest Conservation and Inventory Need. Very little has been documented regarding their distribution, movements, or habitat use. Two separate investigations were conducted on the Yellowstone River beginning in 2004. Both investigations created and designated 5 unique geomorphic river reaches (Table 2). All turtles were captured with baited hoop nets set for 24 to 72 hours. The first investigation began in 2004 and ended in 2005. Turtles were collected turtles using a stratified random sampling design. Spiny soft-shell turtle catch rates increased with increase in designated reach and increased with increase in river km (Figures 31 and 32). No turtles were captured in reach 1, dominated by fines and sand. More turtles were captured upstream in reaches with a substrate dominated by gravel and cobble. The second investigation conducted from 2004-2008 documented similar results to the prior investigation and the majority of spiny soft-shell turtles were captured in reaches 3-5 (Figure 33). Very few turtles were captured in reaches 1 or 2. Within the Yellowstone River, data suggest spiny soft-shell turtles are selecting habitats with gravel-cobble substrate and as a result turtle density increased with increase in river reach and river km.

Table 2. Designated river reaches on the Yellowstone River in Region 7. Differing geomorphic habitat was used in reach designation.

Reach	River km	Ecoregion	Formation: Lithology dominant (secondary)	Channel pattern dominant (secondary)
5	473-378	Sagebrush steppe	Bearpaw: shale (Lance: sandstone/shale/coal) (Judith River: shale/sandstone)	Unconfined anabranching (Partially confined braided, strait, meandering)
4	378-301	Central grassland	Tullock: sandstone/shale/coal (Lance: sandstone/shale/coal)	Partially confined meandering/islands (Partially confined strait)
3	301-195	River breaks	Tullock: sandstone/shale/coal (Lebo member: shale)	Confined meandering (Confined strait)
2	195-56	River breaks	Tongue R: sandstone/shale/coal Ludlow: sandstone/shale/coal (Lance: sandstone/shale/coal) (Pierre: shale)	Partially confined anabranching (Partially confined meandering/islands)
1	56-0	River breaks	Tongue R: sandstone/shale/coal	Partially confined meandering/islands (Unconfined strait/islands)

Reach	River km	Dominant substrate	Channel slope	Sinuosity
5	473-378	Gravel - cobble	0.000578	1.34
4	378-301	Gravel - cobble	0.000552	1.20
3	301-195	Gravel - cobble	0.000631	1.14
2	195-56	Gravel - cobble	0.000551	1.25
1	56-0	Fines - sand	0.000189	1.35

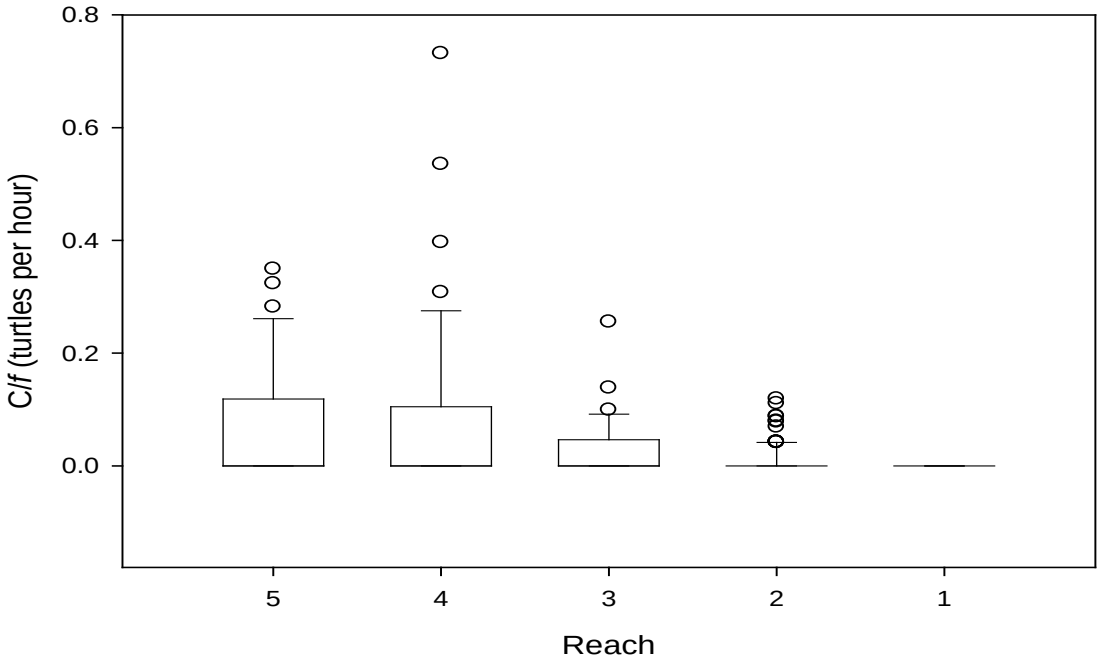


Figure 31. Catch per hour of spiny soft-shell turtles in designated reaches within the Yellowstone River in 2004 and 2005.

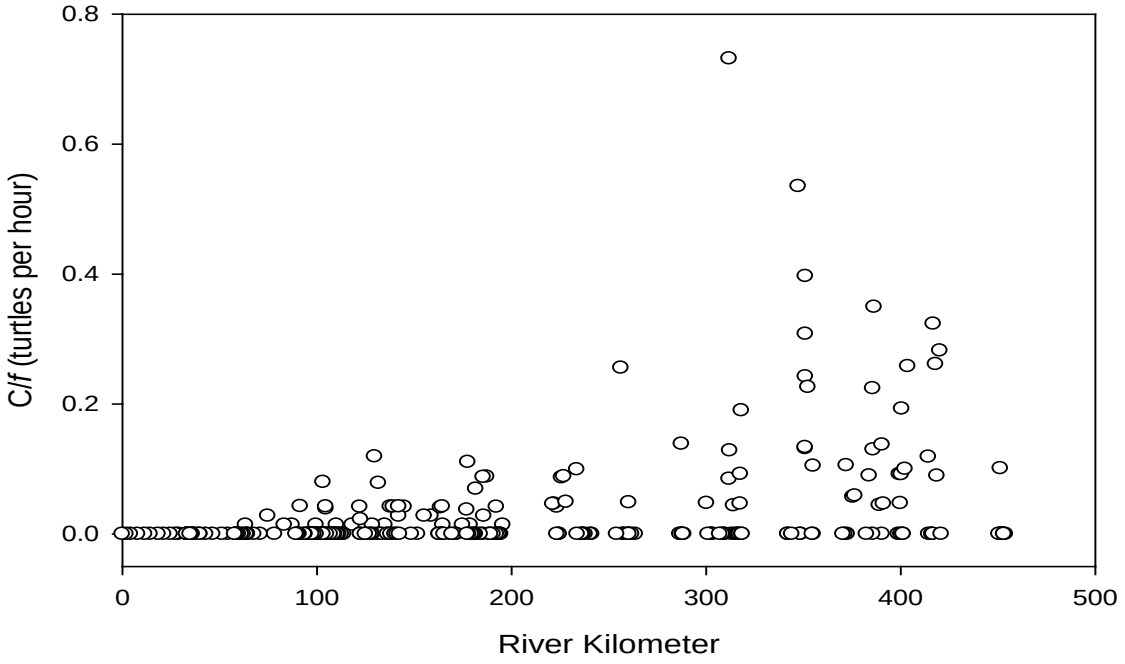


Figure 32. Catch per hour of spiny soft-shell turtles plotted against river kilometer on the Yellowstone River in 2004 and 2005.

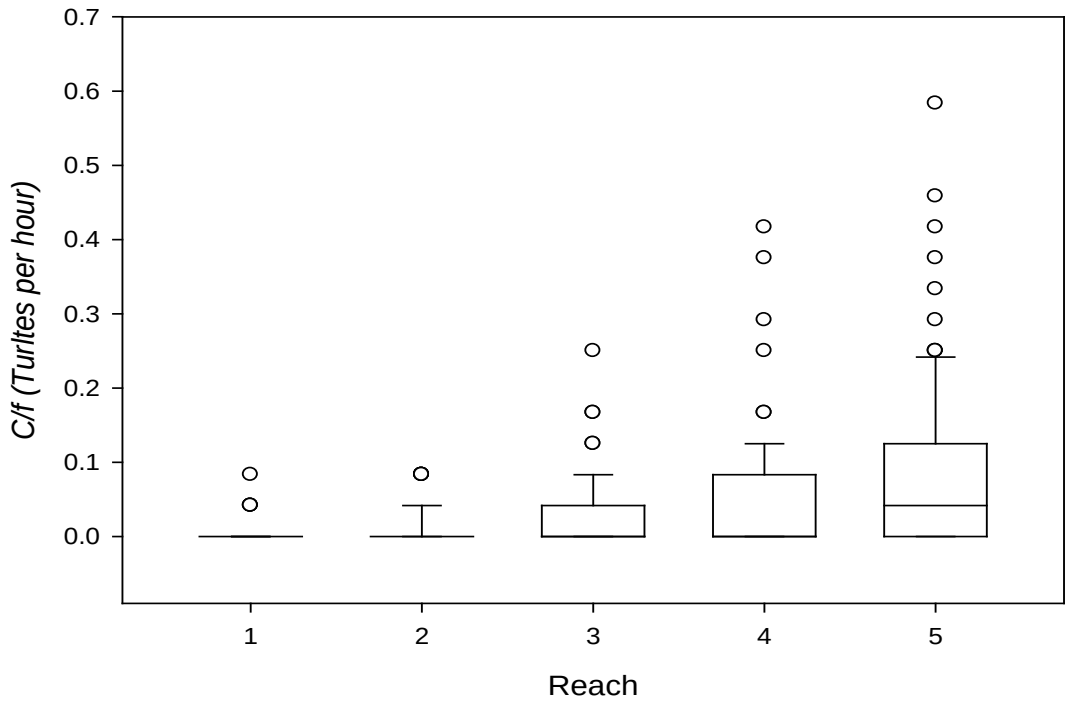


Figure 33. Catch per hour of spiny soft-shell turtles in designated reaches within the Yellowstone River in 2004 and 2008.

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Key words:

Population abundance, structure, and condition.

Sauger, channel catfish, smallmouth bass, shovelnose sturgeon, burbot, walleye, game fish, non-game fish, cyprinids, spiny soft-shell turtle.

Prepared by: Jason Rhoten

Date: March 1, 2011

APPENDIX I

SUMMARY OF ANNUAL CATCH BY TREND SECTION

Table 1. Results of trend sampling in the Yellowstone River, 2001.

Species	N	C/*f* (fish/hour)	Mean Length (mm)	Length Range (mm)	Mean Weight (gm)	Weight Range (gm)
	Forsyth - 120 minutes					
Channel catfish	4	2.00	552	422-733	1798	620-4050
Emerald shiner	10	5.00	65	37-98	--------	--------
Goldeye	5	2.50	336	320-360	302	280-330
Hybognathus spp	20	10.00	106	89-125	--------	--------
Longnose sucker	3	1.50	193	140-223	90	30-120
River carpsucker	8	4.00	405	390-438	913	760-1100
Sauger	1	0.50	465	--------	830	-------
Shorthead redhorse	17	8.50	346	136-497	553	30-1250
Smallmouth buffalo	21	10.50	323	190-433	643	110-1550
Walleye	1	0.50	512	--------	1300	--------
White sucker	7	3.50	355	197-438	586	130-870
	Miles City – 120 minutes					
Blue sucker	1	0.50	753	--------	4000	--------
Carp	24	12.00	493	125-616	1673	25-3080
Flathead chub	4	2.00	150	124-163	30	--------
Goldeye	5	2.50	280	116-362	206	10-360
Hybognathus spp	20	10.00	105	82-127	--------	-------
Longnose sucker	14	7.00	242	180-407	190	50-800
Mountain sucker	1	0.50	148	--------	20	--------
Northern pike	1	0.50	457	--------	630	-------
River carpsucker	9	4.50	406	353-455	952	570-1440
Sauger	2	1.00	354	309-398	370	240-500
Shorthead redhorse	20	10.00	247	163-417	207	50-810
Smallmouth bass	4	2.00	225	125-300	228	10-500
White sucker	1	0.50	222	--------	110	--------
	Fallon - 120 minutes					
Burbot	1	0.50	337	--------	190	--------
Carp	3	1.50	440	277-565	1243	310-2100
Channel catfish	4	2.00	460	204-635	1318	70-3100
Emerald shiner	14	7.00	78	70-93	--------	--------
Flathead chub	10	5.00	137	110-183	19	5-50
Goldeye	20	10.00	200	98-335	94	5-270
Hybognathus spp	8	4.00	102	82-142	20	-------
Longnose sucker	2	1.00	210	200-219	100	80-120

Table 1 (*cont.*)

River carpsucker	6	3.00	418	352-467	1057	560-1480
Sauger	9	4.50	370	280-470	431	150-900
Shorthead redhorse	20	10.00	279	174-468	279	50-1050
Smallmouth buffalo	1	0.50	522	-------	2010	-------
	Intake - 120 minutes					
Carp	1	0.50	617	--------	2200	-------
Emerald shiner	7	3.50	81	64-91	-------	-------
Flathead chub	20	10.00	139	112-187	26	10-60
Goldeye	20	10.00	218	111-395	114	10-610
Hybognathus spp	7	3.50	100	86-117	10	-------
Longnose sucker	1	0.50	176	--------	70	--------
River carpsucker	20	10.00	388	201-468	958	100-1500
Sauger	44	22.00	195	135-404	67	15-440
Shorthead redhorse	9	4.50	192	135-235	77	30-150
Shovelnose sturgeon	1	0.50	563	--------	570	--------
Smallmouth Buffalo	1	0.50	702	--------	5000	--------
Stonecat	1	0.50	96	--------	5	--------

Table 2. Results of trend sampling in the Yellowstone River, 2002.

Species	N	C/*f* (fish/hour)	Mean Length (mm)	Length Range (mm)	Mean Weight (g)	Weight Range (g)
	Forsyth - 365 minutes					
Blue sucker	3	0.49	775	745-800	4085	3575-4500
Burbot	1	0.16	285	--------	100	--------
Carp	57	9.38	534	405-678	2082	910-4550
Channel catfish	28	4.61	529	302-726	1638	220-4160
Emerald shiner	6	0.99	74	64-86	5	--------
Flathead chub	6	0.99	125	104-165	14	5-30
Freshwater drum	1	0.16	360	--------	530	-------
Goldeye	70	11.51	317	193-363	270	70-400
Hybognathus spp	17	2.80	94	78-117	7	5-20
Longnose sucker	13	2.14	358	203-668	425	50-800
Mountain sucker	1	0.16	147	-------	60	-------
Northern pike	1	0.16	620	--------	1610	--------
River carpsucker	56	9.21	388	126-445	781	20-1140
Sauger	26	4.28	388	287-614	535	160-1960
Shorthead redhorse	92	15.13	298	143-498	339	40-1200
Shovelnose sturgeon	7	1.15	828	751-920	3280	2300-5550
Smallmouth bass	44	7.24	264	76-467	463	10-1640
Smallmouth buffalo	7	1.15	471	408-535	1570	990-2240
Sturgeon chub	1	0.16	80	--------	5	--------
Walleye	4	0.66	441	332-583	853	320-1820
White sucker	43	7.07	321	130-428	435	20-860
Yellow bullhead	1	0.16	230	--------	160	--------

Table 2 (*cont.*)

	Miles City - 364 minutes					
Bigmouth buffalo	2	0.33	566	557-574	2925	2680-3170
Black crappie	1	0.16	208	--------	150	--------
Blue sucker	5	0.82	717	663-795	3172	2530-4300
Burbot	1	0.16	400	--------	250	--------
Carp	50	8.24	476	324-576	1488	310-2940
Channel catfish	9	1.48	534	344-690	1673	310-2930
Emerald shiner	8	1.32	77	72-86	--------	--------
Flathead chub	67	11.04	130	95-190	23	5-80
Freshwater drum	3	0.49	427	367-494	1083	640-1550
Goldeye	58	9.56	304	106-374	255	5-410
Hybognathus spp	81	13.34	111	87-150	13	5-30
Longnose sucker	25	4.12	333	205-425	431	80-830
River carpsucker	67	11.04	376	74-498	750	5-1320
Sauger	47	7.74	367	237-528	437	110-1150
Shorthead redhorse	50	8.24	304	175-440	337	70-850
Smallmouth bass	15	2.47	247	56-348	286	5-650
Smallmouth buffalo	16	2.64	512	303-721	2016	300-5000
Sturgeon chub	1	0.16	89	--------	5	--------
Walleye	5	0.82	328	307-341	324	280-380
White crappie	2	0.33	268	194-342	395	100-690
White sucker	6	0.99	287	230-385	290	170-580
	Fallon - 396 minutes					
Blue sucker	2	0.30	732	721-742	3310	3300-3320
Carp	12	1.82	485	200-615	1590	120-2850
Channel catfish	5	0.76	324	145-654	672	30-2800
Emerald shiner	1	0.15	73	--------	--------	-------
Flathead chub	8	1.21	146	121-171	30	20-50
Freshwater drum	1	0.15	447	--------	1240	-------
Goldeye	65	9.85	272	108-358	185	15-410
Hybognathus spp	10	1.52	104	77-140	10	5-20
Longnose sucker	3	0.45	342	304-366	433	310-510
Northern pike	1	0.15	536	--------	990	--------
River carpsucker	17	2.58	366	178-459	724	70-1220
Sauger	21	3.18	372	169-565	453	30-1440
Shorthead redhorse	65	9.85	304	163-485	317	40-1040
Shovelnose sturgeon	4	0.61	602	457-690	978	320-1450
Smallmouth buffalo	1	0.15	494	--------	1650	--------
Stonecat	7	1.06	116	92-144	11	5-20
Sturgeon chub	2	0.30	73	69-77	5	--------
White sucker	2	0.30	300	251-349	270	110-430
	Intake - 370 minutes					
Carp	10	1.61	442	186-710	1728	100-4540
Channel catfish	4	0.65	474	235-580	1218	120-1800
Emerald shiner	3	0.48	82	77-87	5	--------
Flathead chub	30	4.84	167	124-210	44	10-80

Table 2 (*cont.*)

Freshwater drum	1	0.16	295	--------	300	--------
Goldeye	61	9.84	243	104-362	145	10-400
Hybognathus spp	39	6.29	106	91-128	9	5-20
Longnose sucker	1	0.16	267	--------	200	--------
Northern pike	3	0.48	679	568-889	1833	920-3530
River carpsucker	40	6.45	408	168-520	1130	90-2320
Sauger	122	19.68	286	190-475	198	60-830
Shorthead redhorse	42	6.77	253	180-378	195	70-600
Shovelnose sturgeon	21	3.39	499	331-738	512	120-1700
Walleye	2	0.32	402	293-510	730	210-1250
White sucker	2	0.32	281	264-298	210	120-300

Table 3. Results of trend sampling in the Yellowstone River, 2003.

Species	N	C/*f* (fish/hour)	Mean Length (mm)	Length Range (mm)	Mean Weight (gm)	Weight Range (gm)
	Downstream of Rancher Diversion Dam - 110 minutes					
Carp	42	22.91	551.8	355-660	2355.5	640-3920
Channel catfish	28	15.28	561.9	423-710	2108.9	620-5300
Flathead chub	20	10.91	124.5	93-174	18	10-50
Freshwater drum	2	1.09	453.5	390-517	1440	710-2170
Goldeye	23	12.55	327	284-378	310.9	200-470
Longnose sucker	17	9.27	281.1	196-407	248.8	60-600
River carpsucker	15	8.18	396.8	282-450	793.3	290-1050
Shorthead redhorse	93	50.74	342.1	153-507	495	40-1240
Smallmouth bass	8	4.36	260.1	112-380	431.3	20-1060
Smallmouth buffalo	2	1.09	698.5	645-752	5650	4300-7000
Western silvery minnow	2	1.09	111	110-112	10	---
White sucker	10	5.46	345.5	235-432	476	120-920
	Forsyth - 413 minutes					
Bigmouth buffalo	4	0.58	611.5	481-806	3445	210-7090
Blue sucker	2	0.29	735.5	715-756	3875	3000-4750
Burbot	1	0.15	430	---	410	---
Carp	83	12.06	515.2	316-702	1853.7	300-5000
Channel catfish	67	9.74	508.9	295-741	1587.8	240-5020
Emerald shiner	8	1.16	78.3	68-94	10	---
Flathead chub	9	1.31	120.2	95-176	29.4	10-50
Freshwater drum	1	0.15	430	---	1130	---
Goldeye	115	16.72	314.4	272-355	287.3	200-370
Longnose sucker	22	3.20	250.2	88-450	299.5	20-950
Mountain sucker	4	0.58	131.5	112-163	31.3	20-50
River carpsucker	68	9.88	382	225-520	760.2	120-2580
Sauger	45	6.54	361	164-552	456	20-1620
Shorthead redhorse	202	29.36	337.4	142-453	439.3	30-950
Shovelnose sturgeon	14	2.03	810.4	573-915	2700.7	680-4900
Smallmouth bass	39	5.67	223.2	68-403	417.7	10-1280

Table 3 (*cont*.)

Smallmouth buffalo	11	1.60	531.5	389-722	2588.2	900-6200
Walleye	4	0.58	379	223-446	612.5	110-890
Western silvery minnow	4	0.58	105.5	90-112	12.5	10-20
White crappie	1	0.15	172	---	80	---
White sucker	37	5.38	349.3	171-450	534.6	70-900
	Miles City - 400 minutes					
Blue sucker	7	1.05	695.3	610-738	3162.9	2020-3840
Carp	39	5.85	515.7	309-670	2021.7	380-5000
Channel catfish	19	2.85	505.2	69-688	1737.8	380-4800
Emerald shiner	79	11.84	86.4	75-105	5	---
Flathead chub	24	3.60	143.8	110-170	35.7	10-60
Goldeye	55	8.25	307.8	140-307.8	290.2	20-460
Longnose sucker	24	3.60	310.8	125-445	360.8	20-780
River carpsucker	32	4.80	39706	227-458	827.5	150-1200
Sauger	20	3.00	381.4	265-507	508.5	170-1150
Shorthead redhorse	159	23.84	304.9	92-465	368.5	60-1130
Shovelnose sturgeon	3	0.45	796.3	684-868	2853.3	1510-3870
Smallmouth bass	49	7.35	130.5	80-384	87.5	5-1100
Smallmouth buffalo	3	0.45	583.7	480-636	3603.3	1720-5000
Stonecat	2	0.30	134.5	129-140	10	---
Tiger muskey	1	0.15	864	---	5100	---
Walleye	1	0.15	208	---	110	---
Western silvery minnow	21	3.15	104.9	83-139	18.6	10-40
White sucker	4	0.60	353	328-399	530	450-700
	Fallon - 417 minutes					
Blue sucker	5	0.72	660	466-757	3052	750-4550
Burbot	1	0.14	370	---	190	---
Carp	30	4.32	444.3	88-710	1566.9	10-4600
Channel catfish	23	3.31	393.4	70-601	1267.8	20-2270
Flathead chub	28	4.03	139.6	98-207	30	10-80
Freshwater drum	2	0.29	467	394-540	1475	820-2130
Goldeye	37	5.32	197.5	84-327	222.4	10-360
Longnose sucker	4	0.58	264.3	116-371	376.7	270-560
River carpsucker	13	1.87	351.4	72-475	872.7	280-1700
Sauger	71	10.22	380.1	174-549	502.8	40-1460
Shorthead redhorse	66	9.50	335.7	68-480	576.2	20-1350
Shovelnose sturgeon	18	2.59	743.8	584-867	2188.3	770-3930
Smallmouth bass	1	0.14	126	---	30	---
Smallmouth buffalo	2	0.29	300	110-490	1760	---
Stonecat	3	0.43	114.7	106-128	---	---
Walleye	1	0.14	200	---	50	---
Western silvery minnow	4	0.58	102.8	96-117	---	---
	Intake - 444 minutes					
Blue sucker	3	0.41	730	711-750	3690	3380-4010
Carp	7	0.95	42634	187-521	1234.3	100-2000

Table 3 (*cont*.)

Channel catfish	20	2.70	544	132-704	1823.5	100-4500
Emerald shiner	19	2.57	84.7	72-101	---	---
Flathead chub	20	2.70	147	84-217	36.3	10-110
Goldeye	69	9.32	266.9	100-393	192.3	10-400
Longnose sucker	5	0.68	214.6	110-265	124	10-230
River carpsucker	68	9.19	434	213-624	1340.9	100-3050
Sauger	154	20.81	265.7	161-512	172.2	20-1040
Shorthead redhorse	34	4.59	260.9	160-360	220.6	40-500
Shovelnose sturgeon	10	1.35	587.3	315-830	1154	100-2820
Smallmouth buffalo	4	0.54	516	468-575	1892.5	1250-2420
Sturgeon chub	2	0.27	98.5	82-97	---	---
Walleye	5	0.68	217.2	210-228	86	70-110
Western silvery minnow	24	3.24	102.8	57-135	11.5	5-20
White sucker	1	0.14	322	---	380	---

Table 4. Results of trend sampling in the Yellowstone River, 2004.

Species	N	C/*f* (fish/hour)	Mean Length (mm)	Length Range (mm)	Mean Weight (gm)	Weight Range (gm)
	Downstream of Rancher Diversion Dam - 325 minutes					
Blue sucker	1	0.18	683	---	2490	---
Burbot	1	0.18	330	---	220	---
Carp	78	14.39	595.9	379-706	2958.8	680-4200
Channel catfish	33	6.09	576.1	323-752	2336.1	270-5900
Flathead chub	4	0.74	121.8	106-147	30	---
Freshwater drum	1	0.18	378	---	740	---
Goldeye	29	5.35	327.2	297-344	305.2	210-360
Longnose sucker	143	26.38	243.5	70-482	193.6	10-1180
Mountain sucker	1	0.18	118	---	---	---
River carpsucker	86	15.87	403.5	343-457	881.1	530-1420
Sauger	5	0.92	387	336-454	498	250-860
Shorthead redhorse	356	65.68	339.8	149-508	489.8	40-1520
Smallmouth bass	47	8.67	208.8	141-345	176.1	40-770
Smallmouth buffalo	6	1.11	616	483-750	4151.7	1720-8040
Stonecat	1	0.18	104	---	---	---
Western silvery minnow	124	22.88	99.6	79-145	15	10-20
White sucker	53	9.78	343.5	104-451	520.9	170-1070
	Forsyth - 380 minutes					
Bigmouth buffalo	2	0.32	572	528-616	3510	2320-4700
Blue sucker	2	0.32	729	706-752	3715	3250-4180
Burbot	1	0.16	435	---	270	---
Carp	65	10.27	543.7	245-684	2207.5	250-3810

Table 4 (*cont.*)

Channel catfish	25	3.95	537.3	266-711	1994.4	190-3720
Emerald shiner	43	6.79	73.1	56-98	---	---
Flathead chub	6	0.95	141.2	132-159	22	10-40
Freshwater drum	5	0.79	417.4	378-472	924	760-1210
Goldeye	125	19.75	316.1	195-379	275.6	60-450
Longnose sucker	44	6.95	277.8	115-452	322.1	30-920
Mountain sucker	1	0.16	130	---	60	---
River carpsucker	84	13.27	395	268-460	803.9	250-1200
Sand shiner	1	0.16	68	---	---	---
Sauger	21	3.32	372.9	158-489	482.4	20-1100
Shorthead redhorse	269	42.50	349.9	150-505	514.3	50-1180
Shovelnose sturgeon	3	0.47	772	750-803	2430	1780-3310
Smallmouth bass	28	4.42	240.4	129-394	302.9	30-1120
Smallmouth buffalo	16	2.53	549.3	335-665	2682.5	640-5000
Walleye	2	0.32	425.5	387-464	765	530-1000
Western silvery minnow	8	1.26	79.4	74-85	---	---
White sucker	48	7.58	323.9	98-423	468.5	10-850
	Miles City - 360 minutes					
Blue sucker	10	1.67	713.2	678-770	3069	2350-3990
Carp	53	8.83	529.9	260-1495	1906	300-3600
Channel catfish	13	2.17	416.4	256-625	810.8	140-2380
Emerald shiner	5	0.83	76.2	55-93	---	---
Flathead chub	52	8.67	146	106-196	33.3	10-80
Freshwater drum	4	0.67	404.8	372-463	972.5	780-1370
Goldeye	67	11.17	296.2	103-346	265.8	10-360
Longnose sucker	26	4.33	307	209-452	373.5	80-960
Northern pike	1	0.17	617	---	1520	---
River carpsucker	64	10.67	390.6	251-513	831.4	100-1930
Sauger	24	4.00	395	290-485	539.6	130-1070
Shorthead redhorse	260	43.33	332.1	135-494	484.9	20-1310
Shovelnose sturgeon	1	0.17	913	---	4400	---
Smallmouth bass	27	4.50	221.6	92-410	277	10-1140
Smallmouth buffalo	8	1.33	518.8	324-720	2405	250-6100
Walleye	3	0.50	468	393-526	993.3	490-1490
Western silvery minnow	26	4.33	121.3	98-146	21.3	10-60
White sucker	12	2.00	333.8	240-400	495	120-780
	Fallon - 386 minutes					
Carp	22	3.42	536.9	383-652	2133.6	770-3880
Channel catfish	14	2.18	478.8	315-662	1153.6	260-3090
Flathead chub	77	11.98	132.1	92-233	33.3	5-120
Freshwater drum	3	0.47	333.7	287-392	490	320-740

Table 4 (*cont.*)

Goldeye	143	22.24	273.7	86-347	238.9	60-350
Longnose sucker	6	0.93	269.7	202-350	250	80-520
Northern pike	1	0.16	827	---	4150	---
River carpsucker	51	7.93	391.1	133-530	891	20-2330
Sauger	66	10.26	405.9	239-560	568.3	120-1320
Shorthead redhorse	146	22.71	261.2	148-487	293.6	30-1280
Smallmouth bass	4	0.62	167.3	65-207	133.3	120-150
Smallmouth buffalo	8	1.24	429.8	198-582	1530	130-3120
Stonecat	2	0.31	114	86-142	30	---
Walleye	1	0.16	384	---	520	---
Western silvery minnow	85	13.22	103	86-140	---	---
White sucker	3	0.47	336.3	270-428	486.7	220-900
	Intake - 363 minutes					
Bigmouth buffalo	3	0.50	646	591-700	4150	3340-5080
Blue sucker	1	0.17	733	---	3280	---
Burbot	3	0.50	375.7	167-527	361.7	15-680
Carp	15	2.48	460.4	324-603	1424.7	490-2780
Channel catfish	9	1.49	479.9	225-668	1641.1	160-3170
Emerald shiner	9	1.49	77.9	69-86	---	---
Flathead chub	32	5.29	149.9	93-198	37.3	10-70
Freshwater drum	3	0.50	308.3	290-320	390	350-460
Goldeye	200	33.06	273.3	110-372	195.7	10-370
Longnose sucker	2	0.33	273.5	237-310	215	80-350
River carpsucker	118	19.50	415	149-560	1187.2	50-3250
Sauger	187	30.91	313.5	197-500	253.5	50-1000
Shorthead redhorse	54	8.93	271.8	130-392	280.4	30-700
Shovelnose sturgeon	31	5.12	569.8	405-861	952.6	170-3280
Smallmouth bass	1	0.17	214	---	180	---
Smallmouth buffalo	6	0.99	416.3	189-528	1201.7	100-2160
Walleye	3	0.50	363.3	298-473	480	210-920
Western silvery minnow	35	5.79	100	84-128	10	---
White sucker	2	0.33	286	260-312	295	210-380

Table 5. Results of trend sampling in the Yellowstone River, 2005.

Species	N	C/*f* (fish/hour)	Mean Length (mm)	Length Range (mm)	Mean Weight (gm)	Weight Range (gm)
	Downstream of Rancher Diversion Dam - 381 minutes					
Bigmouth Buffalo	1	0.16	601	---	3560	---
Burbot	1	0.16	336	---	240	---
Carp	19	2.99	589	498-679	2820	1570-4020

Table 5 (*cont*.)

Channel catfish	20	3.15	497	365-638	1365	430-3130
Emerald Shiner	139	21.89	78	58-91	4	---
Flathead chub	9	1.42	140	82-206	40	4-90
Freshwater drum	2	0.31	430	420-439	1060	960-1160
Goldeye	108	17.01	323	285-360	305	200-420
Longnose sucker	211	33.23	297	128-417	331	50-730
Mountain Sucker	6	0.94	177	158-205	81	55-130
Northern Pike	1	0.16	635	---	1500	---
River carpsucker	16	2.52	395	338-430	786	460-990
Sand Shiner	1	0.16	60	---	2	---
Sauger	2	0.31	373	350-395	370	320-420
Shorthead redhorse	174	27.40	366	140-475	591	40-1260
Smallmouth bass	27	4.25	270	112-387	393	30-1070
Smallmouth buffalo	5	0.79	646	501-700	4148	1940-4800
Stonecat	1	0.16	170	---	70	---
Walleye	3	0.47	562	475-716	2150	970-4200
Western silvery minnow	424	66.77	99	74-129	9	4-25
White sucker	69	10.87	341	128-435	539	24-1020
	Forsyth - 397 minutes					
Bigmouth buffalo	1	0.15	559	---	2630	---
Burbot	1	0.15	583	---	950	---
Carp	32	4.84	519	313-705	2007	350-5000
Channel catfish	36	5.44	395	239-794	778	120-6150
Emerald shiner	212	32.04	82	62-105	4	---
Flathead chub	8	1.21	156	116-197	38	14-68
Freshwater drum	6	0.91	388	366-442	738	560-1110
Goldeye	333	50.33	317	228-382	298	200-520
Largemouth Bass	1	0.15	122	---	20	---
Longnose sucker	48	7.25	326	198-485	401	90-980
Mountain sucker	3	0.45	185	175-194	80	60-110
River carpsucker	47	7.10	387	315-460	763	430-1250
Sauger	40	6.05	368	265-477	423	128-920
Shorthead redhorse	295	44.58	331	150-523	435	40-1300
Shovelnose sturgeon	1	0.15	792	---	2430	---
Smallmouth bass	94	14.21	258	83-413	325	9-1150
Smallmouth buffalo	3	0.45	545	488-591	2667	1700-3540
Walleye	3	0.45	531	405-767	2303	630-5600
Western silvery minnow	69	10.43	107	84-138	11	4-24
White sucker	40	6.05	330	181-434	484	90-970

Table 5 (*cont*.)

	Miles City - 367 minutes					
Black Crappie	2	0.33	185	184-185	100	100
Blue sucker	7	1.14	702	640-780	2947	2010-3880
Burbot	1	0.16	430	---	390	---
Carp	17	2.78	547	436-648	2239	1150-3650
Channel catfish	7	1.14	486	192-701	1516	50-3900
Emerald shiner	97	15.86	80	67-101	4	---
Flathead chub	16	2.62	144	113-182	31	11-65
Freshwater Drum	1	0.16	380	---	730	---
Goldeye	159	25.99	319	265-397	311	180-410
Longnose sucker	24	3.92	336	223-412	470	140-870
Northern Pike	1	0.16	692	---	2050	---
River carpsucker	34	5.56	379	164-470	777	60-1580
Sauger	37	6.05	381	287-574	483	180-1580
Shorthead redhorse	183	29.92	329	148-495	427	40-1230
Smallmouth bass	21	3.43	272	101-400	406	30-1150
Smallmouth buffalo	5	0.82	554	394-691	2606	810-4000
Stonecat	2	0.33	165	145-185	45	30-60
Walleye	4	0.65	446	430-465	818	800-930
Western silvery minnow	13	2.13	152	49-410	158	1-930
White sucker	15	2.45	322	201-425	421	100-840
	Fallon - 493 minutes					
Bigmouth Buffalo	1	0.12	725	---	6600	
Blue sucker	9	1.10	694	588-753	3008	1390-4010
Burbot	2	0.24	372	248-495	365	90-640
Carp	33	4.02	528	295-706	2239	400-4150
Channel catfish	36	4.38	390	166-726	787	60-3810
Emerald Shiner	4	0.49	84	72-98	4	---
Flathead chub	160	19.47	144	78-222	31	4-118
Freshwater drum	12	1.46	355	920-494	693	324-1560
Goldeye	270	32.86	293	105-353	241	14-430
Longnose Dace	1	0.12	80	---	6	---
Longnose sucker	17	2.07	272	209-445	267	100-950
Northern pike	1	0.12	548	---	1040	---
River carpsucker	20	2.43	381	311-467	756	430-1300
Sauger	82	9.98	396	242-595	579	100-1910
Shorthead redhorse	205	24.95	309	92-492	423	5-1390
Shovelnose sturgeon	5	0.61	786	658-905	2878	1390-4150
Smallmouth bass	1	0.12	311	---	570	---
Smallmouth buffalo	10	1.22	582	331-776	3468	510-7050

Table 5 (*cont*.)

Stonecat	5	0.61	134	108-151	24	8-32
Walleye	3	0.37	382	212-498	683	90-1080
Western silvery minnow	18	2.19	117	85-135	17	5-22
White Sucker	4	0.49	288	229-342	318	150-470
	Intake - 392 minutes					
Bigmouth Buffalo	5	0.77	593	500-678	3444	1910-4600
Blue sucker	1	0.15	633	---	2160	---
Burbot	3	0.46	262	240-308	97	70-140
Carp	10	1.53	541	338-788	2004	900-3710
Channel catfish	15	2.30	429	244-615	827	100-2190
Emerald shiner	321	49.13	79	59-105	4	---
Flathead chub	45	6.89	135	68-214	28	4-100
Freshwater Drum	2	0.31	313	301-324	475	440-510
Goldeye	429	65.66	273	117-347	212	10-420
Longnose sucker	4	0.61	272	208	253	100
Northern Pike	2	0.31	536	440-632	900	570-1230
Plains Minnow	3	0.46	57	55-57	---	---
River carpsucker	120	18.37	401	195-582	1106	140-3260
Sauger	156	23.88	332	170-507	303	30-1000
Shorthead redhorse	104	15.92	247	125-390	179	30-850
Shovelnose sturgeon	41	6.28	552	339-802	741	160-2680
Smallmouth buffalo	8	1.22	649	470-765	3711	1350-5300
Stonecat	1	0.15	100	---	20	---
Walleye	3	0.46	375	360	533	450-640
Western silvery minnow	43	6.58	99	77-126	8	2-17
White sucker	7	1.07	299	270-328	301	210-380

Table 6. Results of trend sampling in the Yellowstone River, 2006.

Species	N	C/*f* (fish/hour)	Mean Length (mm)	Length Range (mm)	Mean Weight (gm)	Weight Range (gm)
	Downstream of Rancher Diversion Dam - 358 minutes					
Bigmouth Buffalo	1	0.17	592	---	3500	---
Carp	26	4.36	574	400-658	2597	570-4500
Channel catfish	43	7.21	515	357-712	1610	370-4500
Emerald Shiner	1	0.17	73	---	---	---
Flathead chub	6	1.01	122	106-145	18	10-25
Freshwater drum	3	0.50	380	362-392	747	640-840
Goldeye	111	18.60	325	238-373	307	140-460

Table 6 (*cont*.)

Longnose sucker	61	10.22	303	125-432	332	20-800
Mountain Sucker	1	0.17	150	---	55	---
River carpsucker	41	6.87	399	344-456	826	430-1250
Sauger	12	2.01	452	346-586	882	320-1750
Shorthead redhorse	265	44.41	303	137-482	386	20-1290
Smallmouth bass	97	16.26	201	85-429	222	10-1520
Smallmouth buffalo	7	1.17	540	470-664	2503	1650-5000
Stonecat	1	0.17	138	---	20	---
Walleye	1	0.17	452	---	930	---
Western silvery minnow	27	4.53	107	80-133	18	10-30
White sucker	52	8.72	323	175-463	453	60-1120
	Forsyth - 395 minutes					
Bigmouth buffalo	1	0.15	492	---	1920	---
Black crappie	1	0.15	200	---	140	---
Blue sucker	4	0.61	728	628-775	3695	1980-4600
Burbot	3	0.46	327	294-348	163	120-210
Carp	22	3.34	528	371-650	2040	900-3020
Channel catfish	51	7.75	440	244-639	956	110-3420
Emerald shiner	65	9.87	83	68-100	---	---
Flathead chub	39	5.92	126	88-162	24	10-50
Freshwater drum	10	1.52	358	322-423	666	360-1210
Goldeye	273	41.47	322	281-377	312	230-520
Longnose sucker	28	4.25	321	227-416	367	100-800
Northern pike	2	0.30	741	682-799	2640	2160-3120
River carpsucker	47	7.14	379	146-426	743	30-1110
Sauger	34	5.16	411	265-600	599	120-1580
Shorthead redhorse	299	45.42	271	100-490	286	10-1210
Shovelnose sturgeon	4	0.61	788	747-835	2218	1750-2640
Smallmouth bass	190	28.86	186	70-394	256	10-1000
Smallmouth buffalo	8	1.22	529	482-636	2104	1550-3700
Walleye	5	0.76	456	223-570	1178	120-2150
Western silvery minnow	280	42.53	96	38-125	12	---
White sucker	38	5.77	333	115-424	477	20-900
	Miles City - 350 minutes					
Black Crappie	1	0.17	266	---	350	---
Blue sucker	5	0.86	703	656-758	3010	2310-3780
Burbot	1	0.17	235	---	60	---
Carp	19	3.26	524	125-626	2134	30-3230
Channel catfish	16	2.74	452	244-642	1040	130-2640

Table 6 (*cont*.)

Emerald shiner	3	0.51	87	84-90	---	---
Flathead chub	21	3.60	154	108-216	40	10-90
Freshwater Drum	5	0.86	377	341-410	782	880-490
Goldeye	144	24.69	314	218-383	302	70-480
Largemouth bass	1	0.17	210	---	180	---
Longnose sucker	48	8.23	346	236-448	452	190-830
River carpsucker	43	7.37	391	238-448	799	160-1370
Sauger	37	6.34	404	282-530	580	160-1310
Shorthead redhorse	282	48.34	286	115-468	322	20-1180
Smallmouth bass	43	7.37	276	99-394	421	10-910
Stonecat	3	0.51	153	143-163	37	30-40
Western silvery minnow	32	5.49	106	93-130	12	10-20
white crappie	1	0.17	192	---	90	---
White sucker	17	2.91	316	191-448	403	70-800
	Fallon - 427 minutes					
Blue sucker	1	0.14	712	---	2740	---
Burbot	1	0.14	302	---	130	---
Carp	12	1.69	485	240-646	1593	210-3450
Channel catfish	22	3.09	444	291-610	899	210-2420
Emerald Shiner	1	0.14	78	---	---	---
Flathead chub	51	7.17	155	92-225	41	10-100
Freshwater drum	1	0.14	372	---	680	---
Goldeye	181	25.43	300	130-376	258	20-410
Green sunfish	1	0.14	100	---	10	---
Longnose sucker	11	1.55	320	230-410	378	130-720
Rainbow trout	1	0.14	484	---	970	---
River carpsucker	12	1.69	371	227-503	755	150-1660
Sauger	45	6.32	400	285-507	586	180-1200
Shorthead redhorse	103	14.47	325	100-494	444	10-1280
Smallmouth bass	1	0.14	336	---	840	---
Walleye	1	0.14	253	---	150	---
Western silvery minnow	24	3.37	116	91-150	14	10-20
White Sucker	5	0.70	340	284-393	504	310-720
	Intake - 381 minutes					
Burbot	5	0.79	273	215-348	202	60-610
Carp	4	0.63	490	366-576	1605	630-2350
Channel catfish	8	1.26	419	64-616	1204	140-2480
Emerald shiner	1	0.16	76	---	5	---
Flathead chub	17	2.68	150	120-212	31	10-60

Table 6 (*cont*.)

Freshwater Drum	3	0.47	171	167-176	33	25-50
Goldeye	447	70.39	273	104-361	212	20-450
Northern Pike	1	0.16	630	---	1150	---
Rainbow trout	1	0.16	438	---	850	---
River carpsucker	18	2.83	327	185-470	634	70-1590
Sauger	194	30.55	309	165-523	255	10-1250
Shorthead redhorse	44	6.93	260	151-395	217	40-450
Shovelnose sturgeon	2	0.31	352	293-411	110	50-170
Smallmouth buffalo	3	0.47	513	473-557	1992	1350-2425
Stonecat	45	7.09	122	103-150	10	10
Walleye	1	0.16	426	---	620	---

Table 7. Results of trend sampling in the Yellowstone River, 2007.

Species	N	C/*f* (fish/hour)	Mean Length (mm)	Length Range (mm)	Mean Weight (gm)	Weight Range (gm)
		Downstream of Rancher Diversion Dam - 382 minutes				
Blue Sucker	3	0.47	739	691-781	3953	2960-5000
Bigmouth Buffalo	3	0.47	614	403-840	4230	1030-8200
Burbot	1	0.16	295	---	110	---
Carp	96	15.08	598	352-706	2933	210-7720
Channel catfish	162	25.44	566	341-763	2112	390-5900
Emerald Shiner	24	3.77	89	---	---	---
Flathead chub	530	83.25	132	105-160	25	10-50
Freshwater drum	2	0.31	402	369-435	965	640-1290
Goldeye	47	7.38	328	300-360	322	250-430
Longnose sucker	61	9.58	258	125-431	209	10-810
Mountain Sucker	2	0.31	163	158-167	60	60-60
River carpsucker	163	25.60	395	226-450	809	190-1250
Sauger	9	1.41	427	314-536	774	240-1700
Shorthead redhorse	456	71.62	322	128-512	434	20-1360
Smallmouth bass	99	15.55	177	70-374	228	10-1050
Smallmouth buffalo	12	1.88	581	452-716	3009	1310-5100
Walleye	5	0.79	604	510-743	3048	1460-6000
Western silvery minnow	92	14.45	111	80-199	13	10-30
White sucker	82	12.88	328	138-446	437	30-1000
Yellow perch	2	0.31	175	172-177	60	50-70

Table 7 (*cont*.)

	Forsyth - 430 minutes					
Blue Sucker	1	0.14	712	---	4200	---
Bigmouth Buffalo	1	0.14	753	---	4500	---
Burbot	1	0.14	310	---	120	---
Carp	68	9.49	497	140-651	1788	30-4000
Channel catfish	72	10.05	474	225-713	1198	90-4120
Emerald Shiner	6	0.84	89	75-102	---	---
Flathead chub	12	1.67	148	116-192	38	10-100
Freshwater drum	2	0.28	353	325-380	570	460-680
Goldeye	100	13.95	326	220-376	333	170-470
Longnose sucker	13	1.81	291	187-415	303	80-730
Mountain Sucker	2	0.28	169	163-175	85	80-90
River carpsucker	152	21.21	393	267-501	781	250-1970
Sauger	22	3.07	358	173-554	452	40-1810
Shorthead redhorse	298	41.58	280	124-435	296	30-860
Shovelnose sturgeon	2	0.28	895	840-950	3810	2920-4700
Smallmouth bass	150	20.93	203	68-407	234	10-1180
Smallmouth buffalo	16	2.23	564	461-675	2786	1280-5000
Walleye	2	0.28	201	166-235	85	40-130
Western silvery minnow	17	2.37	112	80-130	16	10-30
White sucker	49	6.84	337	210-426	455	120-850
	Miles City - 390 minutes					
Black Crappie	1	0.15	230	---	200	---
Blue sucker	6	0.92	741	693-785	3775	2520-4800
Bigmouth buffalo	2	0.31	563	352-774	4350	2700-6000
Carp	52	8.00	510	242-754	1998	230-5300
Channel catfish	55	8.46	464	285-690	1076	200-3700
Emerald shiner	2	0.31	86	84-87	---	---
Flathead chub	20	3.08	150	122-200	33	10-70
Freshwater Drum	7	1.08	406	337-590	907	270-2740
Goldeye	126	19.38	304	120-367	283	10-420
Longnose sucker	10	1.54	340	304-380	370	250-480
River carpsucker	122	18.77	381	96-462	769	270-1400
Sand shiner	1	0.15	60	---	---	---
Sauger	36	5.54	394	204-544	548	70-1340
Shorthead redhorse	225	34.62	327	170-491	437	60-1350
Shovelnose sturgeon	1	0.15	796	---	2250	---
Smallmouth bass	81	12.46	193	65-423	290	10-1420
Smallmouth buffalo	10	1.54	599	455-740	3679	1350-7000
Walley	4	0.62	493	472-527	1243	1090-1510

Table 7 (*cont*.)

Western silvery minnow	2	0.31	123	115-130	15	10-20
White sucker	19	2.92	342	179-420	505	60-850
	Fallon - 462 minutes					
Blue sucker	7	0.91	692	527-833	2776	1280-4200
Burbot	1	0.13	525	---	2310	---
Carp	27	3.51	445	100-612	1459	20-3410
Channel catfish	25	3.25	446	76-662	1267	50-3180
Emerald Shiner	13	1.69	85	78-96	---	---
Flathead chub	79	10.26	140	83-225	31	10-110
Freshwater drum	10	1.30	318	242-405	450	180-830
Goldeye	167	21.69	247	74-365	184	10-370
Longnose sucker	3	0.39	304	210-357	337	110-460
Northern Pike	2	0.26	517	515-518	820	780-860
River carpsucker	71	9.22	381	117-755	828	10-1940
Sauger	92	11.95	387	215-520	507	90-1160
Shorthead redhorse	152	19.74	308	145-437	377	30-900
Smallmouth bass	1	0.13	300	---	450	---
Smallmouth buffalo	2	0.26	435	296-573	1425	440-2410
Walleye	3	0.39	322	170-565	493	70-1300
Western silvery minnow	78	10.13	111	87-140	12	10-30
White Sucker	3	0.39	290	220-345	327	140-480
	Intake - 383 minutes					
Bigmouth buffalo	2	0.31	359	60-658	5000	---
Burbot	2	0.31	347	300-393	260	170-350
Carp	3	0.47	473	403-550	1287	850-1860
Channel catfish	7	1.10	472	258-732	1229	140-3840
Emerald shiner	34	5.33	85	78-95	---	---
Flathead chub	31	4.86	148	102-205	34	10-70
Freshwater Drum	9	1.41	360	260-456	686	210-1410
Goldeye	75	11.75	251	77-366	199	10-480
River carpsucker	93	14.57	388	150-595	990	90-2750
Sauger	222	34.78	325	195-491	276	60-860
Shorthead redhorse	46	7.21	263	131-714	400	20-6200
Shovelnose sturgeon	42	6.58	516	305-708	584	90-1340
Stonecat	1	0.16	155	---	90	---
Western silvery minnow	83	13.00	108	70-127	13	10-20
White Sucker	1	0.16	220	---	450	---
Walleye	3	0.47	217	213-221	80	70-90

Table 8. Results of trend sampling in the Yellowstone River, 2008.

Species	N	C/*f* (fish/hour)	Mean Length (mm)	Length Range (mm)	Mean Weight (gm)	Weight Range (gm)
		Downstream of Rancher Diversion Dam - 339 minutes				
Bigmouth Buffalo	6	1.06	490	83-627	2828	1890-3780
Black crappie	1	0.18	248	---	250	---
Brown trout	1	0.18	125	---	20	---
Burbot	1	0.18	335	---	180	---
Carp	74	13.10	578	377-708	2554	510-4900
Channel catfish	80	14.16	563	394-754	2251	640-6620
Emerald Shiner	33	5.84	71	51-95	---	---
Flathead chub	27	4.78	123	89-180	23	10-70
Freshwater drum	13	2.30	389	315-458	726	120-1200
Goldeye	81	14.34	331	234-395	318	140-450
Largemoth bass	1	0.18	98	---	10	---
Longnose dace	1	0.18	72	---	---	---
Longnose sucker	112	19.83	303	135-480	354	30-1320
River carpsucker	115	20.36	387	133-452	770	40-1170
Sauger	11	1.95	450	370-613	840	390-2160
Shorthead redhorse	313	55.41	334	107-500	483	10-1320
Smallmouth bass	136	24.08	192	68-412	162	10-1160
Smallmouth buffalo	7	1.24	593	505-790	3366	2040-7500
Walleye	23	4.07	540	160-735	2047	30-5200
Western silvery minnow	97	17.17	91	58-147	18	5-115
White sucker	94	16.64	356	119-467	557	10-1150
		Forsyth - 362 minutes				
Bigmouth buffalo	1	0.17	543	---	2340	---
Blue sucker	5	0.83	754	688-796	3452	2370-4600
Brown trout	1	0.17	234	---	100	---
Burbot	1	0.17	358	---	230	---
Carp	84	13.94	533	272-2030	1828	320-4100
Channel catfish	55	9.13	464	236-820	1163	100-6400
Emerald shiner	9	1.49	85	56-109	---	---
Flathead chub	15	2.49	152	101-192	41	Oct-80
Freshwater drum	20	3.32	359	260-456	643	210-1330
Goldeye	200	33.19	327	233-400	306	140-570
Longnose sucker	23	3.82	326	135-421	457	20-1010
Plains Minnow	1	0.17	66	---	---	---
River carpsucker	250	41.48	375	213-495	702	120-1400
Sauger	97	16.10	364	248-568	408	100-1740

Table 8 (*cont.*)

Shorthead redhorse	282	46.79	307	147-520	356	40-1480
Shovelnose sturgeon	7	1.16	826	785-868	2640	2350-3240
Smallmouth bass	127	21.07	273	120-679	654	20-5000
Walleye	5	0.83	439	302-587	1032	230-1970
Western silvery minnow	5	0.83	91	74-111	10	10
White sucker	56	9.29	359	225-432	578	110-980
	Miles City - 408 minutes					
Bigmouth buffalo	3	0.44	641	492-837	3953	1550-7100
Black Crappie	11	1.62	208	128-246	135	10-220
Blue sucker	5	0.74	762	686-824	3983	2925-4500
Bluegill	1	0.15	93	---	10	---
Carp	82	12.06	528	255-715	2149	240-4700
Channel catfish	72	10.59	465	300-840	1143	220-6500
Emerald shiner	15	2.21	90	72-100	---	---
Flathead chub	15	2.21	148	102-211	66	25-110
Freshwater Drum	28	4.12	354	262-588	648	260-2430
Goldeye	144	21.19	317	113-355	315	160-460
Longnose dace	1	0.15	77	---	---	---
Longnose sucker	20	2.94	343	212-412	492	100-820
River carpsucker	283	41.64	377	180-471	721	70-1450
Sauger	121	17.80	376	234-554	453	120-1430
Shorthead redhorse	283	41.64	333	138-497	474	20-1360
Smallmouth bass	144	21.19	198	116-597	177	20-3030
Smallmouth buffalo	22	3.24	570	405-760	3014	880-7700
Stonecat	2	0.29	149	138-160	35	30-40
Walleye	1	0.15	470	---	1050	---
Western silvery minnow	34	5.00	101	74-144	13	10-15
White sucker	30	4.41	351	130-445	562	30-1200
Yellow perch	2	0.29	174	157-190	65	30-100
	Fallon - 410 minutes					
Black crappie	2	0.29	235	233-237	205	180-230
Blue sucker	6	0.88	702	653-793	2960	2320-4600
Brown trout	1	0.15	543	---	1850	---
Carp	84	12.30	511	332-712	1918	100-5200
Channel catfish	61	8.93	438	53-736	1179	10-5300
Emerald Shiner	26	3.81	86	60-100	---	---
Flathead chub	207	30.31	119	72-217	27	10-110
Freshwater drum	14	2.05	343	274-495	584	260-1440
Goldeye	167	24.45	269	72-364	263	10-460

Table 8 (*cont.*)

Longnose sucker	1	0.15	370	---	620	---
Northern pike	1	0.15	826	---	4300	---
River carpsucker	103	15.08	348	160-506	638	45-1880
Sauger	158	23.13	397	185-589	533	60-1510
Shorthead redhorse	225	32.94	260	110-452	268	15-980
Smallmouth bass	17	2.49	441	153-690	2078	50-5500
Stonecat	3	0.44	102	82-132	20	20-20
Walleye	3	0.44	334	165-490	527	60-1180
Western silvery minnow	50	7.32	95	71-135	18	10-30
White crappie	3	0.44	169	153-182	83	70-100
White Sucker	6	0.88	346	286-463	470	270-700
	Intake - 359 minutes					
Bigmouth Buffalo	1	0.17	700	---	6400	---
Blue sucker	2	0.33	750	730-770	3825	3800-3850
Burbot	4	0.67	304	162-470	215	20-530
Carp	27	4.51	550	395-695	2162	260-4400
Channel catfish	44	7.35	358	66-752	666	10-3940
Emerald shiner	200	33.41	83	57-100	---	---
Flathead chub	202	33.74	130	42-243	33	5-110
Freshwater Drum	15	2.51	322	250-437	454	190-1130
Goldeye	145	24.22	290	110-385	264	10-440
Longnose sucker	2	0.33	274	250-298	265	220-310
River carpsucker	69	11.53	357	125-543	757	40-2620
Sand Shiner	1	0.17	57	---	---	---
Sauger	300	50.11	304	147-555	251	20-1330
Shorthead redhorse	92	15.37	244	127-500	188	20-540
Shovelnose sturgeon	32	5.35	542	267-850	746	50-2660
Smallmouth bass	1	0.17	220	---	190	---
Smallmouth buffalo	7	1.17	659	531-750	3829	1500-6000
Stonecat	2	0.33	115	95-135	20	10-30
Walleye	7	1.17	275	163-470	239	30-900
Western silvery minnow	70	11.69	82	64-119	---	---
White sucker	6	1.00	347	304-418	488	320-830

Table 9. Results of trend sampling in the Yellowstone River, 2009.

Species	N	(fish/hour)	Length (mm)	Range (mm)	Weight (gm)	Range (gm)
	Downstream of Rancher Diversion Dam - 419 minutes					
Bigmouth Buffalo	2	0.29	582	563-600	2870	2830-2910
Brown trout	2	0.29	110	93-127	---	---
Carp	98	14.03	585	453-717	2727	1200-5300
Channel catfish	323	46.25	522	292-800	1652	200-6400
Emerald Shiner	24	3.44	84	69-102	---	---
Flathead chub	6	0.86	123	99-162	20	10-40
Freshwater drum	8	1.15	384	345-412	723	440-890
Goldeye	71	10.17	337	285-368	331	200-440
Largemoth bass	1	0.14	182	---	90	---
Longnose dace	3	0.43	87	52-106	15	10-20
Longnose sucker	38	5.44	204	93-430	172	10-1140
River carpsucker	61	8.74	410	288-598	887	320-2100
Sauger	14	2.00	417	317-581	723	240-2400
Shorthead redhorse	278	39.81	351	90-498	547	10-1330
Smallmouth bass	39	5.58	227	105-380	283	20-1120
Smallmouth buffalo	12	1.72	578	453-684	3148	1580-5300
Walleye	6	0.86	578	405-777	2260	560-4800
Western silvery minnow	191	27.35	97	74-130	13	10-20
White sucker	60	8.59	339	116-476	526	10-1220
	Forsyth - 368 minutes					
Bigmouth buffalo	3	0.49	549	517-602	2547	2020-3280
Blue sucker	2	0.33	740	702-778	3945	3290-4600
Carp	77	12.55	524	311-752	2028	460-5400
Channel catfish	68	11.09	473	244-742	1201	100-4700
Emerald shiner	18	2.93	80	74-92	---	---
Flathead chub	5	0.82	149	90-233	93	30-160
Freshwater drum	21	3.42	310	273-384	392	250-660
Goldeye	178	29.02	331	228-385	324	90-510
Northern pike	1	0.16	659	---	1770	---
Longnose sucker	43	7.01	139	71-432	258	10-830
Mountain sucker	1	0.16	109	---	10	---
River carpsucker	238	38.80	375	297-453	687	330-1330
Sauger	45	7.34	364	247-494	402	130-1110
Shorthead redhorse	405	66.03	332	118-470	423	110-1160
Shovelnose sturgeon	1	0.16	815	---	2680	---
Smallmouth bass	72	11.74	237	100-417	260	10-1240
Smallmouth buffalo	21	3.42	557	444-752	2764	1350-6900

Table 9 (*cont.*)

Walleye	4	0.65	408	281-627	933	200-2540
Western silvery minnow	19	3.10	103	86-117	11	10-15
White sucker	47	7.66	382	310-438	667	330-950
	Miles City - 443 minutes					
Blue sucker	4	0.54	681	610-732	2645	1810-3410
Carp	69	9.35	514	321-660	1889	510-4100
Channel catfish	98	13.27	450	210-722	971	80-4180
Emerald shiner	6	0.81	78	74-86	---	---
Flathead chub	26	3.52	129	90-192	29	10-70
Freshwater Drum	11	1.49	319	285-380	409	280-620
Goldeye	92	12.46	329	266-368	328	180-440
Longnose sucker	5	0.68	335	244-426	460	170-770
River carpsucker	159	21.53	385	185-480	754	100-1430
Sauger	50	6.77	384	264-528	491	140-1380
Shorthead redhorse	216	29.26	309	110-496	386	10-1240
Smallmouth bass	46	6.23	244	72-376	262	70-810
Smallmouth buffalo	7	0.95	583	484-703	3136	1620-5800
Stonecat	1	0.14	153	---	40	---
Walleye	3	0.41	271	194-333	197	90-310
Western silvery minnow	24	3.25	99	68-167	15	10-20
White crappie	1	0.14	215	---	120	---
White sucker	13	1.76	370	323-420	587	360-810
	Fallon - 479 minutes					
Blue sucker	3	0.38	589	518-640	1577	1060-1880
Carp	33	4.13	499	292-670	1758	320-3990
Channel catfish	83	10.40	349	145-728	712	20-4700
Emerald Shiner	14	1.75	78	67-88	---	---
Flathead chub	38	4.76	161	91-245	48	10-130
Freshwater drum	10	1.25	371	278-497	852	290-2796
Goldeye	181	22.67	309	95-386	310	20-560
Longnose dace	1	0.13	108	---	---	---
Longnose sucker	2	0.25	212	180-244	85	60-110
Northern pike	2	0.25	835	798-872	3790	2880-4700
River carpsucker	94	11.77	381	208-547	778	110-2450
Sauger	68	8.52	377	154-524	443	20-1050
Shorthead redhorse	219	27.43	273	116-428	259	10-900
Smallmouth bass	7	0.88	268	224-314	297	140-520
Smallmouth buffalo	3	0.38	654	530-765	4620	2060-6300
Stonecat	1	0.13	133	---	30	---

Table 9 (*cont.*)

Walleye	5	0.63	324	221-404	322	100-540
Western silvery minnow	10	1.25	94	73-136	17	10-30
White Sucker	11	1.38	319	92-390	440	5-710
	Intake - 397 minutes					
Bigmouth Buffalo	2	0.30	587	581-592	3660	3600-3720
Brown trout	1	0.15	494	---	1230	---
Burbot	1	0.15	167	---	20	---
Carp	6	0.91	565	468-692	2502	1260-4500
Channel catfish	13	1.96	413	53-591	928	50-2120
Emerald shiner	171	25.84	77	56-95	---	---
Flathead chub	78	11.79	140	77-243	35	10-130
Freshwater Drum	15	2.27	309	260-387	392	250-760
Goldeye	87	13.15	292	96-374	281	20-610
Northern pike	3	0.45	549	494-603	1117	840-1520
River carpsucker	112	16.93	413	128-588	1221	20-2760
Sauger	100	15.11	326	191-521	302	70-1270
Shorthead redhorse	53	8.01	241	105-380	171	20-520
Shovelnose sturgeon	12	1.81	527	403-770	673	210-2040
Smallmouth buffalo	5	0.76	498	330-680	2198	490-4600
Stonecat	1	0.15	195	---	60	---
Walleye	4	0.60	325	202-418	478	80-740
Western silvery minnow	15	2.27	109	92-120	10	10
White crappie	1	0.15	285	---	310	---
White sucker	2	0.30	224	102-345	490	---

Table 10. Results of trend sampling in the Yellowstone River, 2010.

Species	N	C/*f* (fish/hour)	Mean Length (mm)	Length Range (mm)	Mean Weight (gm)	Weight Range (gm)
	Downstream of Rancher Diversion Dam - 294 minutes					
Bigmouth Buffalo	2	0.41	655	558-752	4315	2580-6050
Brown trout	8	1.63	252	201-299	183	110-290
Carp	84	17.14	581	432-783	2925	1380-6260
Channel catfish	209	42.65	477	257-764	1338	80-4250
Emerald Shiner	206	42.04	82	45-96	---	---
Flathead chub	31	6.33	113	55-163	19	10-40
Freshwater drum	6	1.22	365	351-393	740	600-990
Goldeye	60	12.24	339	289-382	398	260-580
Longnose dace	1	0.20	68	---	---	---

Table 10 (*cont.*)

Longnose sucker	156	31.84	244	85-414	195	20-820
Mountain sucker	1	0.20	115	---	20	---
Mountain whitefish	5	1.02	181	138-273	68	30-170
River carpsucker	116	23.67	394	309-462	822	440-1230
Sand Shiner	4	0.82	64	56-70	---	---
Sauger	9	1.84	461	373-601	1009	430-2040
Shorthead redhorse	350	71.43	375	114-491	643	20-1430
Smallmouth bass	72	14.69	213	56-402	319	20-1270
Smallmouth buffalo	14	2.86	621	460-750	4243	1520-8850
Walleye	3	0.61	574	440-685	2627	1120-3660
Western silvery minnow	220	44.90	91	80-125	---	---
White sucker	76	15.51	323	120-465	491	20-1170
	Forsyth - 310 minutes					
Bigmouth buffalo	1	0.19	567	---	2210	---
Blue sucker	1	0.19	201	---	100	---
Brown trout	1	0.19	667	---	1990	---
Burbot	1	0.19	300	---	150	---
Carp	60	11.61	531	268-690	2083	300-4300
Channel catfish	114	22.06	462	298-754	1163	220-5520
Emerald shiner	69	13.35	82	61-97	---	---
Fathead minnow	1	0.19	62	---	---	---
Flathead chub	27	5.23	106	77-144	17	10-40
Freshwater drum	6	1.16	350	317-407	595	400-970
Goldeye	95	18.39	343	310-376	396	280-540
Longnose sucker	8	1.55	299	204-443	398	100-1100
River carpsucker	154	29.81	379	306-450	723	320-1220
Sauger	23	4.45	361	305-475	408	240-920
Shorthead redhorse	252	48.77	328	115-494	470	20-1200
Shovelnose sturgeon	4	0.77	858	818-900	3198	2600-3890
Smallmouth bass	55	10.65	224	75-424	282	30-1030
Smallmouth buffalo	15	2.90	583	415-718	3175	1040-5750
Walleye	4	0.77	413	362-467	690	500-1040
Western silvery minnow	128	24.77	91	76-124	---	---
White sucker	41	7.94	355	93-448	635	40-1140
	Miles City - 149 minutes					
Bigmouth buffalo	6	2.42	643	554-741	4133	2100-6300
Black crappie	3	1.21	161	145-190	57	20-80
Blue sucker	2	0.81	761	740-782	3925	3450-4400
Brown trout	1	0.40	252	---	170	---

Table 10 (*cont*.)

Carp	75	30.20	529	301-698	2161	380-4400
Channel catfish	68	27.38	498	196-687	1367	60-3310
Emerald shiner	60	24.16	87	78-108	---	---
Flathead chub	66	26.58	112	83-180	22	10-50
Freshwater Drum	22	8.86	351	315-430	566	400-950
Goldeye	126	50.74	331	121-380	367	20-570
Longnose sucker	38	15.30	290	191-431	349	70-980
River carpsucker	249	100.27	387	284-515	763	320-2200
Rock bass	1	0.40	146	---	80	---
Sauger	67	26.98	346	152-471	364	30-890
Shorthead redhorse	316	127.25	308	115-445	359	10-1020
Shovelnose Sturgeon	1	0.40	772	---	2050	---
Smallmouth bass	37	14.90	261	96-368	378	20-880
Smallmouth buffalo	2	0.81	654	562-745	5225	2550-7900
Stonecat	2	0.81	116	111-120	20	20
Walleye	6	2.42	415	124-708	1358	300-4000
Western silvery minnow	93	37.45	104	81-136	20	---
White crappie	1	0.40	282	---	260	---
White sucker	28	11.28	2	190-441	327	40-960
	Fallon - 210 minutes					
Black crappie	1	0.29	176	---	90	---
Blue sucker	3	0.86	733	717-750	3533	3000-4080
Carp	51	14.57	551	260-702	2437	260-4900
Channel catfish	179	51.14	448	62-723	1142	20-4400
Emerald Shiner	112	32.00	90	76-104	---	---
Flathead chub	75	21.43	147	81-217	42	10-110
Freshwater drum	24	6.86	353	310-474	634	400-1600
Goldeye	83	23.71	302	105-371	332	20-550
Longnose sucker	1	0.29	172	---	60	---
Northern pike	2	0.57	616	582-650	1200	780-1620
River carpsucker	69	19.71	379	225-560	729	160-2550
Sauger	125	35.71	316	137-626	345	10-1400
Shorthead redhorse	84	24.00	304	140-479	343	30-1240
Smallmouth bass	3	0.86	348	212-533	987	170-2250
Smallmouth buffalo	7	2.00	510	284-771	3088	320-9000
Stonecat	5	1.43	126	73-144	30	20-40
Walleye	13	3.71	399	204-558	705	80-1590
Western silvery minnow	9	2.57	105	84-116	---	---
White Sucker	2	0.57	370	365-375	560	500-620

Table 10 (*cont*.)

	Intake - 178 minutes					
Bigmouth Buffalo	10	3.37	719	637-843	6981	3575-12000
Black crappie	1	0.34	245	---	250	---
Burbot	1	0.34	240	---	80	---
Carp	17	5.73	466	318-665	1623	460-3880
Channel catfish	21	7.08	482	293-731	1211	200-5240
Emerald shiner	25	8.43	88	62-102	---	---
Flathead chub	76	25.62	133	79-225	37	10-100
Freshwater Drum	8	2.70	361	253-505	743	280-1420
Goldeye	178	60.00	272	72-382	294	10-580
Northern pike	4	1.35	556	464-670	1108	620-1820
Rainbow trout	1	0.34	500	---	1200	---
River carpsucker	46	15.51	379	55-510	926	180-2040
Sauger	227	76.52	202	126-535	109	10-1290
Shorthead redhorse	27	9.10	224	123-374	146	20-600
Shovelnose sturgeon	5	1.69	389	268-445	236	80-320
Smallmouth buffalo	1	0.34	670	---	4800	---
Walleye	5	1.69	476	436-518	1074	660-1430
Western silvery minnow	23	7.75	101	81-120	---	---
White bass	4	1.35	121	100-157	30	10-60
White sucker	3	1.01	175	134-216	60	20-100

APPENDIX II

Sauger Sampling Efficiency on the Lower Yellowstone River

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Abstract

The Yellowstone River fish assemblage has been sampled annually each autumn (August, September, and October) with boat-mounted electrofishing equipment to monitor individual species and overall population trends. This trend data has been utilized to make management decisions. Specifically, trend data has greatly influenced decisions and conclusions of sauger *Sander canadensis* management. It is well recognized that sampling efficiency varies in response to environmental factors such as discharge, turbidity, conductivity, time of day, water temperature, substrate, water depth and others. The magnitude of these effects on sampling efficiency is ambiguous and resultantly disregarded. A relatively small change in the number of fish captured suggests proportionately large changes in abundance because of small sample sizes collected. Therefore, given the low number of captures, the effect of ambient conditions on catch rates greatly influence perceived population trends. Adult sauger were telemetered to address study objectives in the month of April 2005 (N=50), 2006 (N=50), and 2007 (N=70). These fish were relocated in autumn 2005 and 2006 and the likelihood of capture was investigated using a randomly selected gear type (electrofishing or trammel net) under ambient environmental conditions. Only electrofishing gear was used to capture fish relocated during the autumn of 2007. The resulting capture efficiency for trammel nets and electrofishing combined was 13.6%. Electrofishing caught more fish but likelihood of capture was not significantly different between gear types ($P = 0.562$). Analysis of ambient environmental conditions suggested the combined model was statistically significant ($P = 0.001$) when all factors were modeled. Depth was the only statistically significant independent coefficient ($P = 0.001$) when modeled separately. The projected 90-day net median movement of sauger during trend survey season was 0.0 km.

Introduction

The Yellowstone River fish assemblage has been sampled annually each autumn (August, September, and October) with boat-mounted electrofishing equipment since 1998. Trend sampling includes 5 different locations; Forsyth (downstream of Cartersville Diversion), Miles City (above and below the Tongue River confluence), Fallon (above and below the O' Fallon Creek confluence), Intake (downstream of Intake Diversion) and since 2003, Hysham (downstream of Rancher diversion). Trend areas are approximately 9.6 river km in length and are sampled once in August, September and October. All species encountered are collected, enumerated, measured, and, excepting cyprinids, weighed. An index of abundance (catch per effort) was/is calculated for all species captured. Data collected are analyzed, interpreted and influence management decisions. Currently, sauger *Sander canadensis* management is of high priority.

Sauger were historically present in the Yellowstone River and its tributaries from its confluence with the Missouri River upstream to the thermal transition zone that influences changes in the Yellowstone River fish assemblage near Big Timber, Montana (Brown 1971; Haddix and Estes 1976; Holton and Johnson 2003). Over the past 100 years, sauger distribution in the Yellowstone watershed has decreased as a result of habitat loss, fragmentation, and alteration, primarily related to the installation of hydroelectric and low-head irrigation diversion dams on tributaries (McMahon 1999). Distribution in tributaries has decreased by 95%; sauger are considered rare in the Tongue and Big Horn rivers in Montana, but still occur in the Powder River (McMahon and Gardner 2001). The sauger is listed as a species of special concern in Montana (Montana Natural Heritage Program 2006). However, despite these declines, 2008 and 2010 Yellowstone River trend survey work has documented increased catch rates of sauger downstream of Miles City.

The decline in sauger population has been attributed to various factors including drought, migration barriers, entrainment and exploitation (McMahon 1999, Jaeger 2004). Where plausible, efforts are being made to reduce detrimental impacts. Jaeger (2004) suggested exploitation alone does not prevent sauger recovery but because potential for over-harvest exists monitoring should be continued. Sauger are highly susceptible to overexploitation seasonally when spawning aggregations of entire stocks gather in discrete spawning areas (St. John 1990; Penkal 1992) and migratory behavior results in unusually high concentrations of sauger at dams and diversion structures (Nelson 1969; Hesse 1994; Pegg et al. 1996). Overexploitation during periods of aggregation has been implicated in the collapse of several sauger fisheries (Hesse 1994; Pegg et al. 1996, Maceina et al. 1998). Anglers on the Yellowstone River target potential areas of aggregation and have become more sophisticated and efficient at harvesting sauger in recent years (Stewart 1992; McMahon 1999).

Increased angler efficiency has prompted concern among biologists. Monitoring the sauger population has become increasingly important. Currently, autumn electrofishing trend data are the best available data used to project trends in sauger population abundance. However, a relatively small change in the number of fish captured suggests proportionately large changes in abundances because of small sample sizes collected. It is well established that sampling efficiency varies in response to multiple environmental factors. Therefore, given the low number of captures associated with autumn trend surveys, the effect of ambient conditions on catch rates greatly influence perceived population trends. In addition, sauger movement may potentially further influence capture rates observed during autumn electrofishing. Unfortunately, the magnitude of these effects on sampling efficiency is ambiguous and resultantly disregarded.

Research was conducted attempting to describe the magnitude of the of these effects on sauger sampling efficiency. The objectives of the study were: 1) to quantify the efficiency of electrofishing and trammel nets for capturing Yellowstone River sauger 2) to determine if ambient conditions (abiotic factors) influenced capture efficiency 3) to determine if sauger movements influence capture efficiency and 4) to determine if correction factors could be developed to moderate the effects of environmental stochasticity on catch rate data

This information could ultimately result in a more accurate and precise assessment of sauger population trends thereby supplying managers with well defined data to make imperative management decisions.

Study Area

The study area consists of the 473 km of the Yellowstone River downstream of the confluence with the Big Horn River (Figure 1). Mean annual discharge at the USGS gauging station in Miles City, Montana, is 323 m^3/s and mean annual peak discharge is 1480 m^3/s (Figure 2). River geomorphology varies throughout the study area in direct response to valley geology; straight, sinuous, braided, and irregular-meander channel patterns occur (Silverman and Tomlinsen 1984). The channel is often braided or split and long side channels are common. Islands and bars range from large vegetated islands to unvegetated point and mid-channel bars (White and Bramblett 1993). Substrate is primarily gravel and cobble upstream of river kilometer 50 and is primarily fines and sand below (Bramblett and White 2001). The fish assemblage is comprised of 49 species from 15 families, including eight state-listed Species of Special Concern and one federally listed endangered species (White and Bramblett 1993; Carlson 2003). The primary deleterious anthropogenic effect on the fish assemblage is water withdrawal for agriculture and associated entrainment of fish (White and Bramblett 1993). About 90% of all water use on the Yellowstone River is for irrigation, which corresponds to annual use of 1.5 million acre-feet (White and Bramblett 1993). Six mainstem low-head irrigation diversions dams occur in the study area. The largest and downstream-most of these, Intake Diversion, diverts about 38 m^3/s and entrains about 600,000 fish of 34 species during the mid-May to mid-September irrigation season (Hiebert et al. 2000).

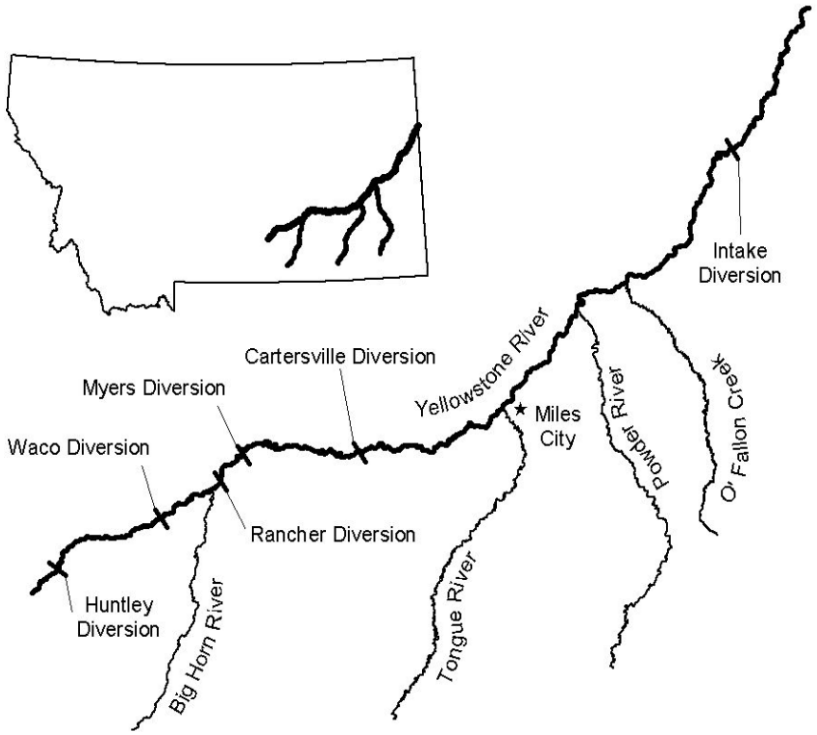

Figure 1. The Yellowstone River, its major tributaries, and diversion dams.

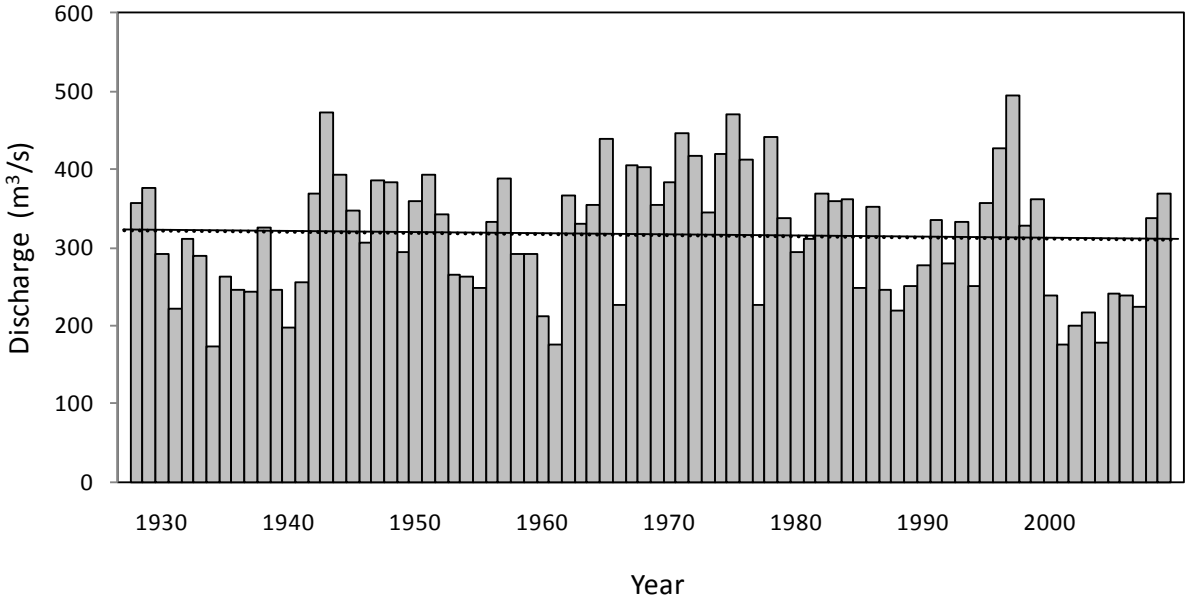

Figure 2. Mean annual discharge of the Yellowstone River at Miles City, 1929-2009. Dashed line represents mean annual discharge calculated since 1927.

Methods

Fifty radio transmitters with mortality sensors were surgically implanted into adult sauger at known spawning locations between the Powder River and Fallon, Montana in April 2005 and 2006. Fish were captured while congregated in spawning areas by drifting a 125' 1"X8" trammel net. Tricaine Methanesulfonate (MS 222) was used to anesthetize sauger prior to surgical procedures. An incision on the ventral side of the fish allowed for implantation of a SR-M11-18 Lotek radio transmitter. Upon recovery from anesthesia sauger were contained in a holding tank and their health was visually monitored for approximately 30 minutes before they were released. Following spawning, radio tagged fish redistributed to home locations 5 to 120 kilometers from their initial capture location; therefore, data were not biased by site-specific initial capture probabilities.

Fish were relocated during autumn 2005 and 2006 using radio receivers. Fish location was determined by quadrangulation using a combination of buoys and GPS. Trials with transmitters of known location indicated that relocation accuracy was within 1 to 2 meters of actual radio location. Upon relocation of radio tagged fish a gear type (electrofishing or trammel net) was randomly selected for use. Various ambient conditions (discharge, temperature, conductivity, turbidity, depth, substrate, cloud cover, atmospheric pressure, and prior temperature fluctuation) were recorded in conjunction with the success or failure of the appropriate gear type. Cloud cover was ranked on a scale 1-5 with 1 representing clear sky and 5 overcast sky. The effect of environmental factors on sampling efficiency was modeled using logistic regression models. In addition

multiple individual ambient conditions were analyzed in an attempt to construct probabilistic models describing the magnitude of effect varying conditions have on sampling efficiency, and develop coefficients for those ambient conditions.

Effort varied slightly in 2007 to maximize information returned. Seventy radio transmitters with mortality sensors were surgically implanted in 2007. The additional 20 radios were to increase sample size and narrow confidence intervals. Fish relocation and capture attempt protocol remained consistent apart from capture gear was limited to electrofishing only. A single sample method was selected to increase the sample size and narrow confidence intervals on ambient environmental conditions under investigation. Capture efficiency between years (2005, 2006, 2007) was also analyzed to document bias that may have occurred as a result of increased expertise of sampling protocol and capture gear.

Upon location of a telemetered sauger the coordinates were documented. Individual fish located two or more times during the efficiency trial were plotted on a map and river km location recorded. Net movement rate (km/d) was calculated for each telemetered sauger. Net movement rate was calculated by dividing the change in river kilometer between successive relocations by the number of days that had elapsed between relocations. A positive rate indicated upstream movement and a negative rate indicated downstream movement (Bramblett 1996). The 90 day (typical trend duration) projected net movement was calculated by multiplying net movement rate by 90.

Results

A total of 49, 64, and 182 capture trials occurred in 2005, 2006 and 2007. Of the 295 capture trials, 40 sauger were recaptured. The resulting capture efficiency for trammel nets and electrofishing combined was 13.6%. Electrofishing recaptured 34 (14.1%) fish in 241 trials while trammel nets recapture 6 (11.1%) fish in 54 trials. Electrofishing caught more fish but likelihood of capture was not significantly different between gear types (P = 0.562 Figure 3). Electrofishing efficiency in 2005, 2006 and 2007 was not significantly different (P=0.709 Figure 4). Data analysis of year was conducted on electrofishing in 1.5m of water or less.

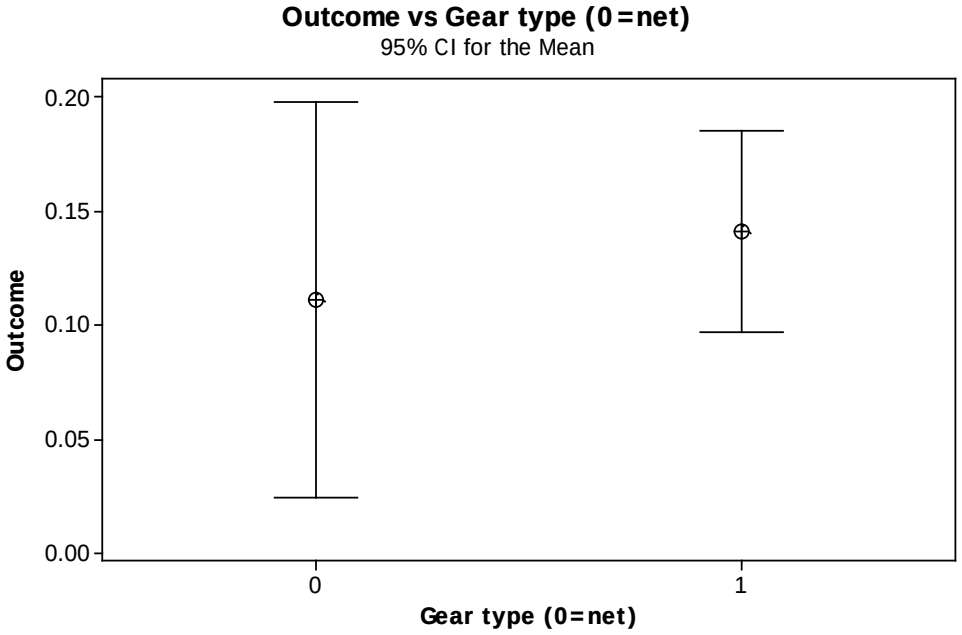

Figure 3. Efficiency of trammel netting (0=net) and electrofishing (1=electrofishing). No significant difference was detected between the two different gear types (P=0.562).

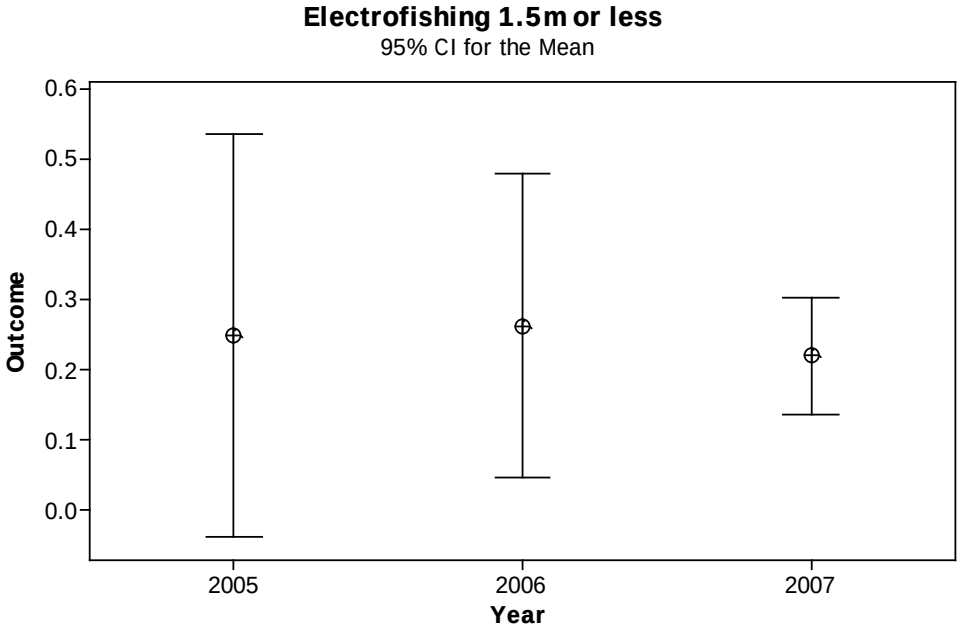

Figure 4. Efficiency of electrofishing between 2005, 2006, 2007. No significant difference was detected between the different years (P=0.709).

Ambient environmental factors were analyzed from 2005, 2006 and 2007 efforts. A regression analysis suggested the combined model was statistically significant (P = 0.001) when all factors were modeled together. Only the coefficient for depth was statistically different from zero (P = 0.001) when modeled individually with outcome as response (Table 1). All but two sauger were captured at depths less than 1.5 m (Figure 5). Regression analysis between depth and discharge (P=0.019, R^2= 1.9%), turbidity (P=0.005, R2=2.7%), conductivity (P=0.262, R^2=0.4%), temperature (P=0.876, R^2=0.0%), cloud cover (P=0.338, R^2=0.3%), atmospheric pressure (P=0.001, R^2=4.1%), 48 hour prior temperature fluctuation (P=0.046, R^2=1.4%), and 24 hour prior temperature fluctuation (P=0.898, R^2=0.0%) were modeled (Table 2).

Table 1. Results of a binary logistic regression modeled between outcome and various ambient conditions

	P value
Discharge	0.934
Turbidity	0.631
Conductivity	0.430
Temperature	0.901
Depth	0.001
Substrate	0.198
Day of Year	0.495
Atmospheric Pressure	0.773
Cloud Cover	0.525
48 hour prior temperature fluctuation	0.668
24 hour prior temperature fluctuation	0.139
Combined Model	0.001

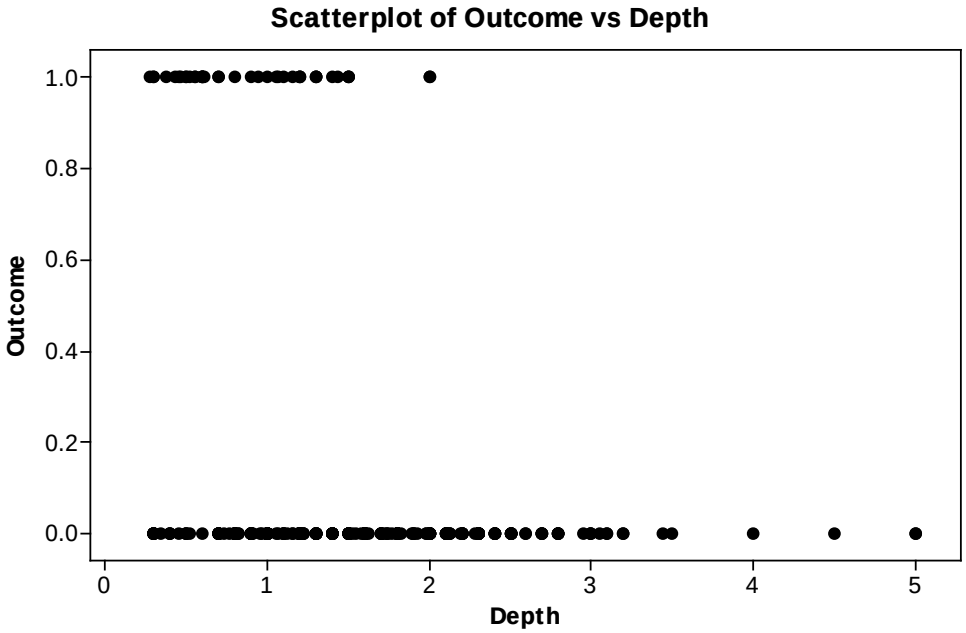

Figure 5. Outcome of sampling trial compared to depth of fish. An outcome of 1 represents capture and an outcome of 0 represents no capture.

Table 2. Results of a regression model between depth and various ambient conditions.

	P value	R-Sq value
Discharge	0.019	1.9%
Turbidity	0.005	2.7%
Conductivity	0.262	0.4%
Temperature	0.876	0.0%
Substrate	0.460	0.0%
Day of Year	0.226	0.5%
Atmospheric Pressure	0.001	4.1%
Cloud Cover	0.338	0.3%
48 hour prior temperature fluctuation	0.046	1.4%
24 hour prior temperature fluctuation	0.898	0.0%

There were 183 relocations of sauger that could be used to analyze sauger movement (Table 3). Both median and mode sauger total movement were 0.00 km. Total movement ranged from 0.00 km to 191.35 km. Daily net movement median and mode were 0.00 km and ranged from 0.00 km to 9.11 km. The projected 90 day net movement had a median of 0.00 km and a mode of 0.00 km. The maximum projected movement for a sauger was 820.08 km.

Table 3. Total movement, daily net movement, and projected 90 day net movement of sauger in the Yellowstone River telemetered at different times during the months of August, September, and October.

Total Movement (km)		*Daily Net Movement (km)*		*Projected 90 Day Net Movement (km)*	
Mean	1.67	Mean	0.09	Mean	8.13
Standard Error	1.23	Standard Error	0.07	Standard Error	6.03
Median	0.00	Median	0.00	Median	0.00
Mode	0.00	Mode	0.00	Mode	0.00
Minimum	0.00	Minimum	0.00	Minimum	0.00
Maximum	191.35	Maximum	9.11	Maximum	820.08
Count	183	Count	183	Count	183

Discussion

No significant difference was detected in capture gear efficiency between electrofishing and trammel nets. Following data collection in 2006 simulations indicated that a significant difference in capture efficiency between gears would not be detected until roughly 1000 capture trials occurred. This would have taken about 15 years to accomplish at the observed rate of sampling. In an attempt to build statistically significant models to generate day-specific correction factors and moderate the effects of environmental stochasticity on trend data only electrofishing was utilized in 2007. In addition, electrofishing was selected because it required less effort and less time to effectively deploy after a fish had been located. Decreased required effort and increased number of sauger radio tagged increased sampling trials in 2007. The combined sampling total for 2005 and 2006 was 113 trials while in 2007 there were 182 trials conducted.

Despite concern regarding experience bias associated with effectively locating and navigating the electrofishing equipment over the known fish location, there was no detectable difference between sampling efficiency in 2005, 2006 or 2007. Comparison of capture efficiency was limited to electrofishing trials in 1.5 meters of water or less because this was the depth all but 2 captures occurred at. Although no significant difference was detected, confidence intervals for electrofishing in the year 2007 were

tighter and therefore the expected efficiency more precise. Tighter confidence intervals can likely be attributed to increased sample trials in 2007.

When all ambient conditions were combined and modeled with outcome as the response, significance was detectable but only the coefficient depth was significant when ambient conditions were modeled separately. All but 2 fish were captured in 1.5 meters of water or less. If a fish was deeper than 1.5 meters multiple variables decrease efficiency. Electrical field intensity decreases with increased distance from the source, hence fish at greater depths experience lower electrical field intensity. In addition, fish that experience electro-taxis and succumb to electro-narcosis at greater depths are less likely to be seen by the individual netting fish. Electrofishing efficiency beyond 1.5 meters is likely reduced due to the precision of location of a specific radio tagged fish. Location precision decreases as depth increases, thus increasing depth decreases the likelihood the boat will directly pass over the location of the telemetered fish and expose it to the electrical field.

In attempt to develop a usable correction factor for trend surveys fish depth needed to be further analyzed to correlate it with an ambient condition. Biologist personal observations have documented decreased capture efficiency with unstable weather conditions, extreme high or low turbidities, temperatures, discharge and others. Although significant p values were detectable in regression analysis of depth and various other ambient conditions, low R^2 values deface the significant p values. Despite lack of correlation of fish depth to ambient conditions, field experiences of biologist suggest ambient factors contribute greatly to capture efficiency observed in trend surveys.

Significant fluctuations in tend survey capture rate within the same year can be attributed to fluctuations in capture efficiency. Sauger movement throughout the duration of August, September, and October is minimal. The median projected sauger movement over a 90-day period beginning in August was 0.00 km suggesting little sauger movement occurs during this period. These findings are in agreement with Jaeger (2004) where he documented minimal movement of sauger in autumn months. Documented minimal autumn movement suggests that sauger catch rate fluctuations within the same year can be attributed to fluctuations in capture efficiency, not migration.

Trend surveys are vital to making management decisions and adjustments to capture rates are required to properly interpret the data. Until further knowledge is acquired in regards to correction factors, biologist should use personal experience and knowledge to interpret the observed capture rates of trend surveys.

In conclusion, no significant difference was detected between trammel net and electrofishing capture efficiency therefore we suggest continued use of electrofishing equipment to conduct trend surveys. Efficiency of electrofishing is dependent upon depth and efforts should be focused on depths 1.5m or less. Construction of a probabilistic model describing the effect of varying conditions on sampling efficiency could not be created with data we collected. Re-locations of radio tagged sauger suggested fish movement throughout the duration of fall trend surveys is limited. Observed fluctuations in catch rate between trend survey months within the same year can be attributed to fluctuations in capture efficiency, not fluctuations in abundance. Therefore, fluctuations in catch rate can be further interpreted from prior or post trend surveys within the same year and biologist should use personal experience and knowledge to interpret the observed capture rates of trend surveys.

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