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North Platte River Programmed Creel Survey, Gray Reef Dam to Casper, 2009.

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Abstract

A programmed creel survey was conducted on the North Platte River from Gray Reef Dam downstream to Robertson Road between March 15, 2009 and October 31, 2009. An estimated 18,293 anglers spent 85,176 hours fishing during this period. Pressure (hours fished) increased 233% since the last programmed creel survey in 1995. The largest increase in pressure was due to increased boat use which was 15 times the 1995 boat angler pressure. Overall catch rate was 0.93 fish per hour with boat anglers having higher catch rates (1.12 fish per hour) than shore anglers (0.63 fish per hour). Rainbow trout was the most commonly caught species with brown and cutthroat trout incidental in the creel. Harvest rate has declined from nearly 100% in 1973 to 1.7% in 2009. The estimated hooking mortality is now more than double the estimated harvest. This was the first time guided trip anglers were separated from non-guided trip anglers. Twenty eight percent of all interviewed anglers were on a guided trip and all guided trips were boat trips (47% of all boat anglers). Recommendations were made to set the catch rate objective to a proportional angling success calculated on a catch rate of 0.5 fish per hour ($PAS_{0.5}$) = 0.50 and adjust the population objective to a level at which $PAS_{0.5}$ = 0.50 is achieved.

Introduction

The Gray Reef tailwater section of the North Platte River begins at Gray Reef Dam, in south-central Natrona County and flows in a northeasterly, then easterly direction through the towns of Casper and Glenrock. It is classified as blue ribbon water (supporting greater than 600 pounds of salmonids per mile) throughout the entire 87 mile reach from Gray Reef Dam to the Dave Johnston powerplant dam (WGFD 2008, 2009). Trout density rapidly decreases downstream of this point due to increasing temperatures and turbidity. The tailwater characteristics of this reach along with trout populations and biomass, degrade with increasing distance from Gray Reef Dam. Fishing pressure tends to follow the same pattern.

Trout are not native to the North Platte drainage but have been widely introduced beginning as early as 1880 (Wiley 1993; Baxter and Stone 1995). Prior to the construction of mainstem reservoirs and the resulting tailwaters, the North Platte River through this reach would have been unlikely to support salmonids. The game fish assemblage would have included sauger

Sander canadense (now extirpated), shovelnose sturgeon *Scaphirhynchus platorynchus* (also extirpated), channel catfish *Ictalurus punctatus* (native strain likely extirpated, persist through stocking), black bullhead *Ameiurus melas* and stonecat *Noturus flavus* (latter two still present in drainage; Baxter and Stone 1995; WGFD file data). With the construction of Pathfinder Dam in 1909 and Alcova Dam in 1938, the North Platte River was able to support salmonids.

While Pathfinder and Alcova reservoirs resulted in favorable habitats for trout, the tailwater was still wrought with problems. The river below Alcova dam was subject to large flow fluctuations and periodic de-watering (Peterson and Leik 1958). Large fish kills were common when flows were reduced in summer and illegal seining was apparently rampant at low flows (WGFD file data). The problems were exacerbated downstream of Casper where raw sewage from the city along with petroleum seepage from the banks could result in complete fish kills to Guernsey Reservoir, 120 miles downstream (Peterson and Leik 1958). Gray Reef dam was completed in 1961 and served as a re-regulation reservoir to allow a constant instream flow of at least 330 ft^3/s to fulfill downstream water rights and promote better water quality below Casper (Wenzel 1993).

Annual trout stocking began in 1936 (WGFD file data). Rainbow trout *Oncorhynchus mykiss* and brown trout *Salmo trutta* have been the most frequently stocked species. Snake River cutthroat trout *Oncorhynchus clarkii* ssp. have been periodically stocked as well as Bear River cutthroat *O.c. Utah* and Yellowstone cutthroat *O.c. bouvieri*. Other salmonids that have occasionally been stocked include brook trout *Salvelinus fontinalis*, lake trout *Salvelinus namaycush* and grayling *Thymallus arcticus*.

Stocking has played an integral role in the maintenance of a quality trout fishery in the Gray Reef tailwater, but often with variable success (Peterson and McMillan 1973; Mavrakis and Yule 1998; Deromedi 2000). Relatively low river flows fostered the accumulation of fine sediments thereby degrading the quality of spawning habitat (Wenzel 1993). High flows in the mid 1980's resulted in strong yearclasses of naturally recruited trout (WGFD 1987; Dey and Annear 1993). Flushing flows of 4,000 cfs were recommended and found to be effective at mobilizing fine sediments and have been conducted annually since 1993 (Wenzel 1993; Leonard 1995). Bailey (2002) evaluated the contribution of stocked fish between Gray Reef Dam and Casper and found natural reproduction as a result of flushing flows was sufficient to maintain populations and catch rates at acceptable levels. As a result, the management strategy was changed from basic yield to wild in 2002.

Biennial fish population sampling in the upper three miles of river below Gray Reef Dam showed a significant negative trend in the number of adult fish per mile over the 10-year period spanning 1998 – 2008 (WGFD 2009). The decline did not seem to correspond with the elimination of stocking, as stocking continued through 2002. Further, strong year-class production (> 1,000 fish per mile at age 1) was apparent in 2001, 2003 and 2005, although no significant increases in the population of adult fish were detected. Over this same time-frame, angler use had increased noticeably (Al Conder, Casper Regional Fisheries Supervisor, personal communication) a trend further supported by an estimate of boat anglers in 2001 (Bailey 2002).

Estimates of angler use and harvest had previously been collected in 1973 (Peterson and McMillan 1973) and 1995 (Mavrakis and Yule 1998). The creel limit was reduced to two trout, one over 20 inches in 1987 in response to a Conoco pipeline gasoline spill and resultant massive fish kill (Wichers 1987). Mavrakis and Yule (1998) noted that harvest had decreased considerably compared to the 1973 harvest estimate, but exploitation was still around 43% annually in the Gray Reef to Lusby reach. The creel limit in this reach was further restricted in

1998 to one trout, all trout less than 20 inches must be released, and anglers were restricted to the use of artificial flies and lures only. The regulation change was in response to low numbers of large fish and suspected high grading (releasing a smaller fish already reduced to possession after catching a larger fish) by bait anglers (Al Conder, personal communication). While boat anglers were enumerated in 2001, no estimates of harvest or bank angler pressure were generated, although spot creel data was collected on both bank and boat anglers (Bailey 2002). Without recent data on exploitation, it was impossible to determine if anglers were at least partially responsible for the significant decline in trout numbers.

The 2009 programmed creel survey was initiated to address five objectives. The first objective was to determine if anglers are harvesting enough fish to have population level impacts. Second, to determine if the decreased population has impacted angler catch rates. Third to identify who is using the resource, specifically guides, non-residents, tackle types etc. Fourth, creel data is needed to formulate objectives for this fishery in terms of catch rates. Lastly, to help identify when stocking needs to be considered to maintain angler catch rates. While this study alone does not address the latter, data is needed to correlate measured fish populations with angler catch rates over many years.

Study Area

The creel survey was conducted on a 39.4 mile reach beginning at Gray Reef Dam and terminating at the Robertson Road Bridge on the west end of Casper (Figure 1). While there is an additional 47.6 miles of blue ribbon trout water below this point, the vast majority of pressure occurs in the study section. There are two special regulation areas in this reach. From river mile 0.0 at Gray Reef Dam downstream to river mile 7.6 at the upper boundary of the Lusby Public Fishing area, the regulation is one trout per day or in possession, all trout less than 20 inches shall be released to the water immediately, fishing by the use of artificial flies and lures only. From river mile 7.6 downstream to river mile 30.5 (Bessemer Bend Bridge) the limit is three trout per day or in possession, no more than one trout shall exceed 16 inches. The remainder of the river is under general statewide regulations (six trout per day or in possession, no more than one shall exceed 20 inches).

Angler access to the river is good. Approximately 43% of the total stream miles are accessible on at least one bank via Bureau of Land Management lands, State Lands, Natrona County Park, WGFD walk-in area, WGFD public fishing easement, or WGFD fee title land. Six developed boat ramps are available for float anglers.

Methods

A stratified, two-stage programmed creel survey was conducted March 15 through October 31, 2009. Each month consisted of two separate strata (weekdays and weekend days). Four sample days were randomly selected for each strata with the constraint that 2 weekdays and two weekend days would be sampled within each two-week period. The length of a fishing day was defined as ½ hour before sunrise to ½ hour after sunset while the sampling day was defined as one hour after sunrise to one hour before sunset to ensure adequate visibility during aerial counts. The length of the fishing and sample day was adjusted every two weeks. Two angler counts were conducted per sampling day. The start time of the first count was randomly selected

within the first ½ of the sampling day. The second count was initiated at an interval equal to ½ of the sampling day length after the first count.

Angler counts were conducted from a fixed wing aircraft flying at an average altitude of 150 feet above the river and average ground speed of 85 mph. Whenever possible, the direction of the count (upstream or downstream) was alternated between days and counts. With prevailing southwesterly winds, downstream counts could only be conducted with wind speeds < 15 mph. If downstream counts were not possible, upstream counts were used. It generally took 25-35 minutes to complete a count. When conditions were too hazardous for flight, counts were conducted from the ground (8 of 240 counts were conducted from the ground). Ground counts generally took 45 minutes to one hour to complete and were initiated at the prescribed start time. Since many boats are not visible from the ground, a count of boat trailers was recorded and converted to anglers using interview data and cross referenced with the first aerial count for that particular day if available.

The observer recorded the total number of shore and boat anglers. Only people who appeared to be actively fishing at the time of observation were counted as anglers. In other words, the rower of a drift boat was not considered to be fishing at that moment, while someone who was re-tying or wading across the river with a fishing rod in hand was considered to be fishing. Anglers who used some form of watercraft for conveyance down the river were considered boat anglers, even when the boat was beached and the anglers were wadefishing at the time of observation. The observer plotted the exact location of all anglers on aerial photos (approximate scale = 1:25,000) while counting. The spatial count information was used to create shapefiles in arcmap containing the location, date, and count time for each boat and shore angler.

Creel interviews were gathered by one or two roving creel clerks. Information gathered included interview time, boat or shore angler, tackle type, residency, location, hours fished, complete or incomplete trip, number of fish released or harvested by species and whether it was a guided trip or not. Incomplete trip anglers were given a postage paid card and asked to complete when done fishing for the day. Anglers could mail in the card or deposit in one of several drop boxes located at popular access areas. The card contained the date and interview number and asked anglers to fill in the total hours fished for that day and total fish released and harvested by species. Card returns were used to increase the number of completed trips.

Interview and count data were entered into the creel.mdb database. Once all interview data were entered, a copy of the database was made where interviews were updated based on card returns. Both databases were sent to Kevin Gelwicks, Aquatic Assessment Crew Supervisor, for analysis with WyoCreel version 1.63.

Pressure estimates were further broken down by river reach (Figure 1). Shore angler reaches and boat angler reaches deviate slightly in total distance. Boat angler reaches begin and end at established boat ramps, while shore angler reaches are split at public land boundaries at each boat ramp. Shore angler breaks were made at Gray Reef Dam (GR), Pete's Draw (PD), the upper boundary of the Lusby PFA (UL), Government Bridge (GB), the lower end of the Sechrist PFA (LS), Bessemer Bend Bridge (BB) and Robertson Road Bridge (RR). Boat angler breaks were made at the following boat ramps: Gray Reef (GR), Lusby (L), Government Bridge (GB), Sechrist (S), Bessemer Bend (BB) and Robertson Road (RR). The average number of anglers per count, per day, by reach was determined from the count maps. The averages for each reach were summed by month and divided by the entire river total to get the fractional average number counted by reach. The estimated pressure for each reach was derived by adjusting total river pressure each month by the fractional average number. Estimates of angler days were not

calculated as there were significant differences in the average length of a complete trip among reaches as well as some reaches being hampered by low number of complete trip interviews.

Mean catch rates were calculated using individual catch rates from anglers reporting having fished for at least one hour. Individual catch rates were also used to calculate proportional angling success (PAS) based on the percent of anglers reporting a catch rate of ≥ 0.5 fish per hour ($PAS_{0.5}$; Bailey 2007).

Differences among estimates were tested with a log-transformed *Z*-test (Thompson et al. 1998). Differences in mean individual catch rates were tested using either two-sample t-tests or one-way analysis of variance (ANOVA). Differences in $PAS_{0.5}$ were tested using chi-square. Differences were determined to be significant at $P \leq 0.10$. When multiple comparisons were made, a Bonferroni correction was applied to alpha. All statistical tests were run using Minitab Version 15.

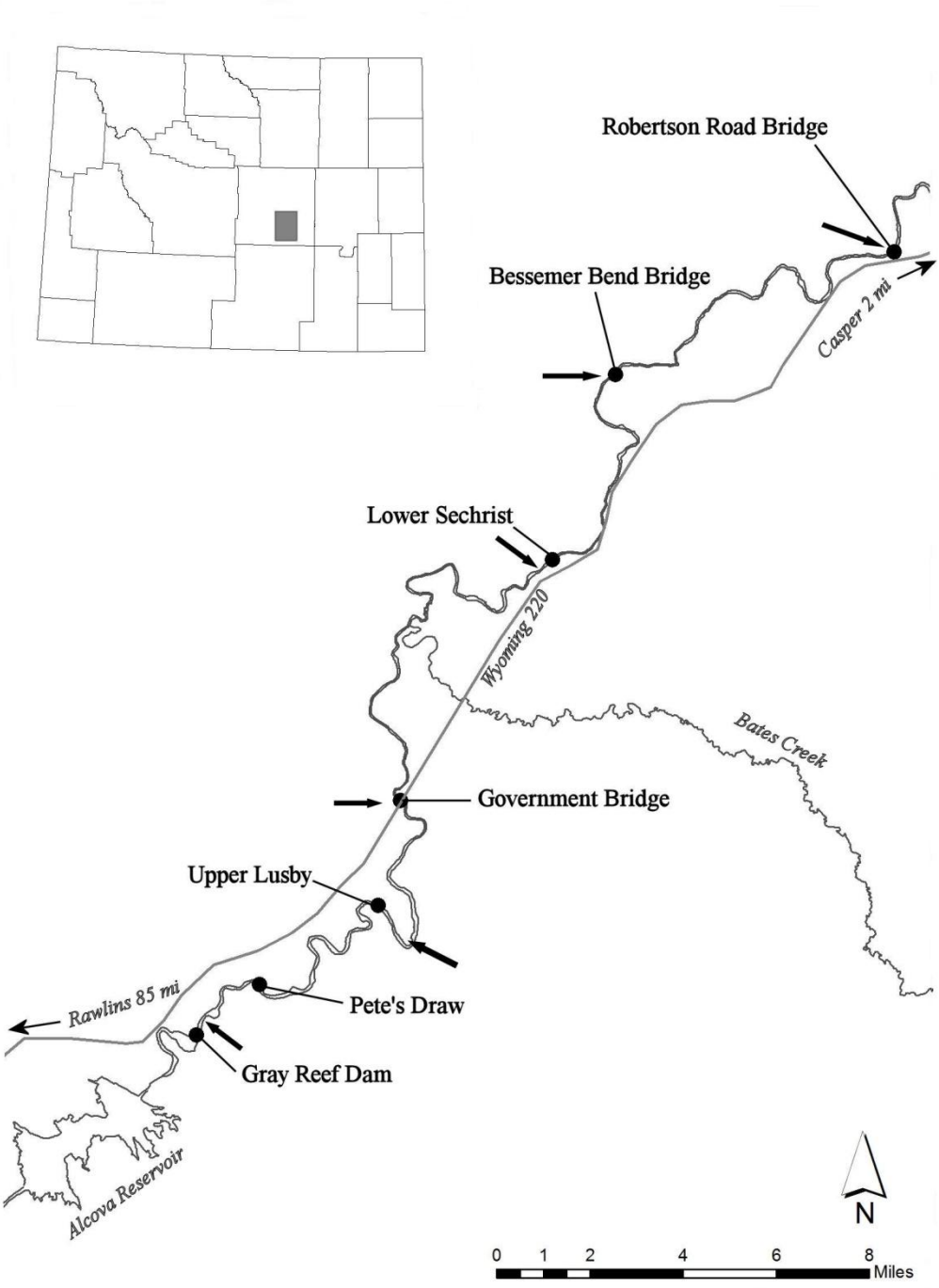

FIGURE 1. Map of the Gray Reef to Robertson Road reach of the North Platte River. Dots represent bank angler breaks, arrows denote boat ramps.

Results

Effect of Creel Cards

Of the 1,675 anglers interviewed, 837 were incomplete trips and were given a creel card. Two hundred sixty eight cards were returned yielding a return rate of 32%. Without card data, 50% of the total interviews were complete trips. The addition of card returns resulted in 66% of all interviews being complete trips. The addition of card data significantly reduced the estimated number of bank anglers as this angler category shouldered the bulk of incomplete interviews (757 of 837 total). The addition of card data had minimal influence on other categories (Table 1). Only estimates using the card data will be discussed beyond this point.

TABLE 1. Various creel estimates and coefficient of variation (CV; %) with *Z*-statistic and associated *P*-value for significance tests on the difference between data sets with card returns and without card returns ($\alpha = 0.02$).

	With Card		Without Card			
Category	Estimate	C.V.	Estimate	C.V.	*Z*	*P*
Anglers	18,293	18.1	23,359	17.1	0.98	0.15
Bank	9,457	8.3	14,547	7.4	3.86	<0.001
Boat	8,836	9.5	8,812	9.6	0.02	>0.50
Total Catch	79,036	8.6	79,503	8.6	0.04	>0.50
Total Harvest	1,350	19.6	1,332	23.3	0.04	>0.50

Summary of Interviews

Creel clerks conducted 1,675 angler interviews between March 15 and October 31. April and May yielded the most interviews of any months with 350 and 363 interviews respectively. March and October were the slowest months with 98 and 99 respectively.

The majority of anglers (61.7%) were non-residents. The majority of non-residents (65.9%) were from Colorado. In total, 42 states and three foreign countries were represented in the sample (Figure 2). The majority of resident anglers (81.5%) were from Natrona County. In total, 19 of 23 Wyoming counties were represented (Figure 3). Nonresidents fished significantly longer during a single day on average (5.8 hours) than did residents (4.2 hours) (t=9.5, P < 0.001).

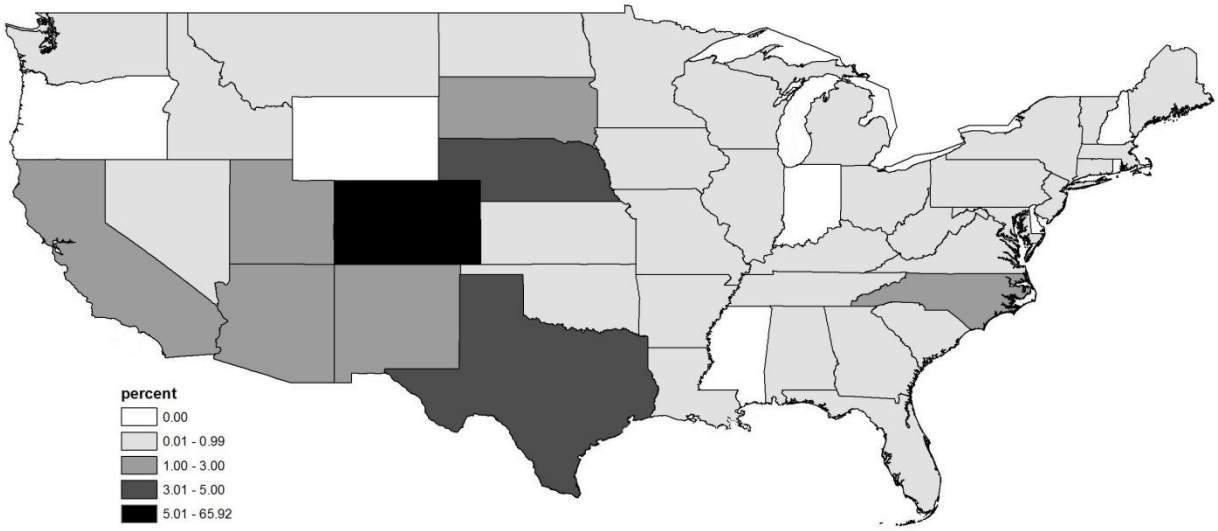

FIGURE 2. Percent of non-resident anglers by U.S. state. Not shown are Alaska, Hawaii, New Zealand and Canada with 0.1% each, and Europe with 0.2%. North Platte River, Gray Reef Dam to Robertson Road, March 15-October 31, 2009.

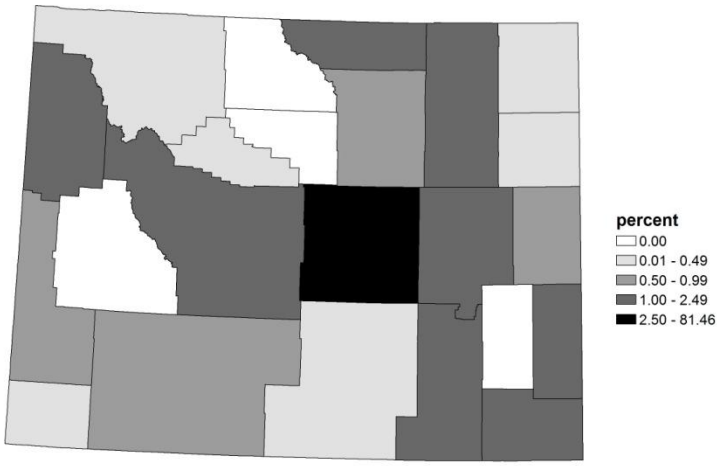

FIGURE 3. Percent of Resident anglers by county. North Platte River, Gray Reef Dam to Robertson Road, March 15-October 31, 2009.

The majority of anglers reported fishing with flies only (80.4%). Bait only was the second most common fishing method at 8.9% of anglers, followed by lures only (7.8%). Proportionately, non-residents were more likely to fish with flies exclusively (92.2%) than residents (61.4%), while residents were more likely to fish with bait (19.5%) than non-residents (2.3%; Figure 4).

Of the 1,675 anglers interviewed, 373 reported being on a guided trip (28.1%). All guided trips were boat trips representing 46.7% of all boat angler interviews. The majority of guided anglers (79.1%) were non-residents. All guided anglers reported fishing with flies exclusively.

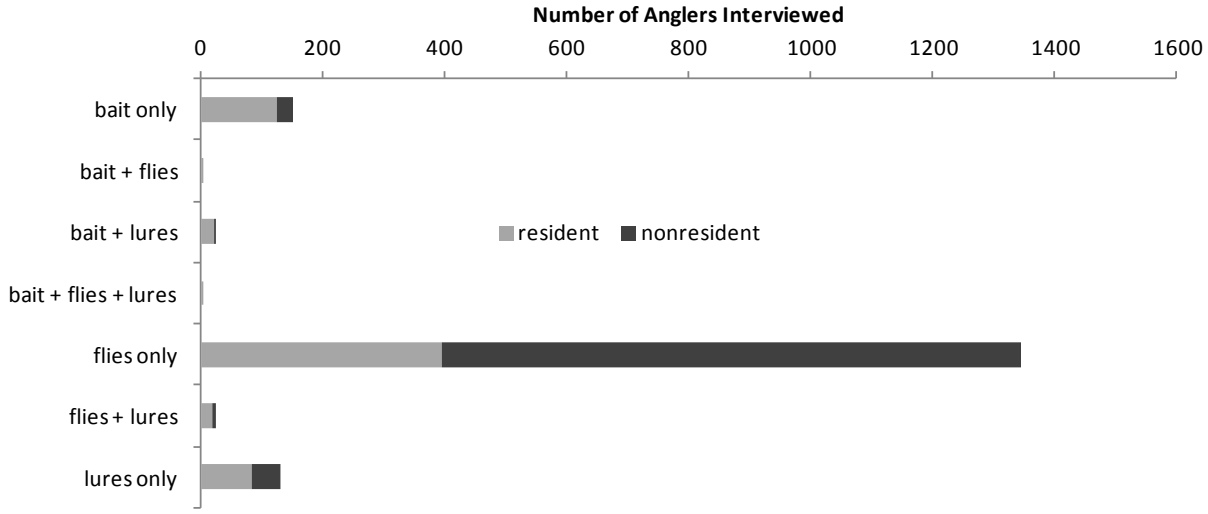

FIGURE 4. Terminal tackle usage by resident and non-resident anglers. North Platte River, Gray Reef Dam to Robertson Road, March 15-October 31, 2009.

Pressure

Anglers fished an estimated 85,176 hours (SE= 8,008) from March 15 to October 31, 2009. Boat angler pressure (51,450 hrs, SE = 5,196) was significantly greater than bank angler pressure (33,726 hrs, SE = 2835) ($Z = 3.21$, $P < 0.001$). Pressure was highest in May, with this month alone accounting for nearly 27% of the total effort (Figure 5).

The estimated number of anglers (18,293, SE = 3,304) was more equitably split between bank (9,457, SE=782) and boat (8,836, SE=843) with no significant difference between the estimated number of each ($Z = 0.54$, $P = 0.27$) (Figure 6).

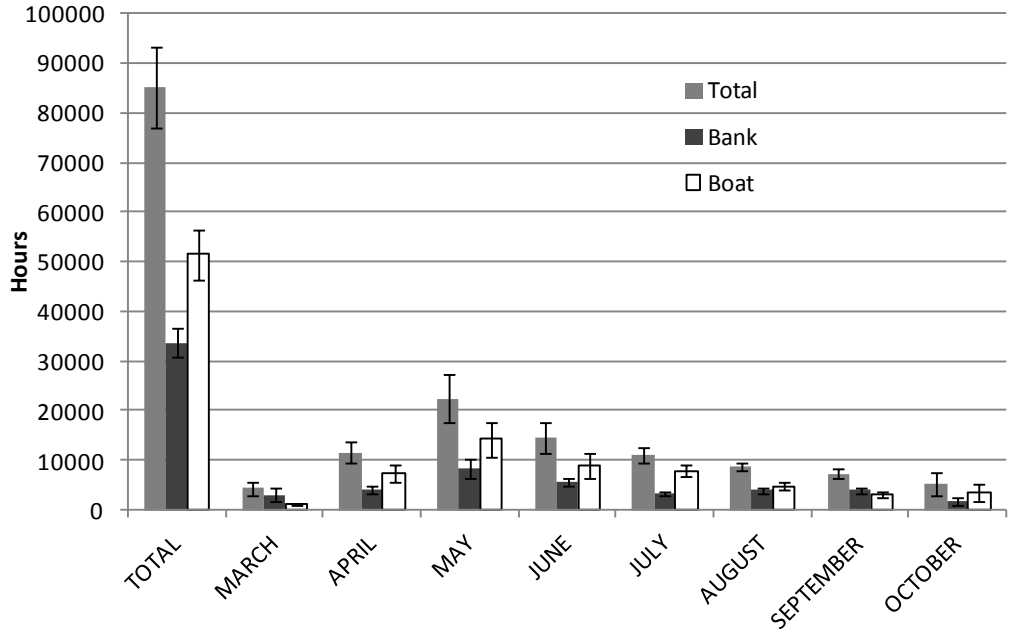

FIGURE 5. Estimated hours fished (± 1 SE). North Platte River, Gray Reef Dam to Robertson Road, March 15-October 31, 2009.

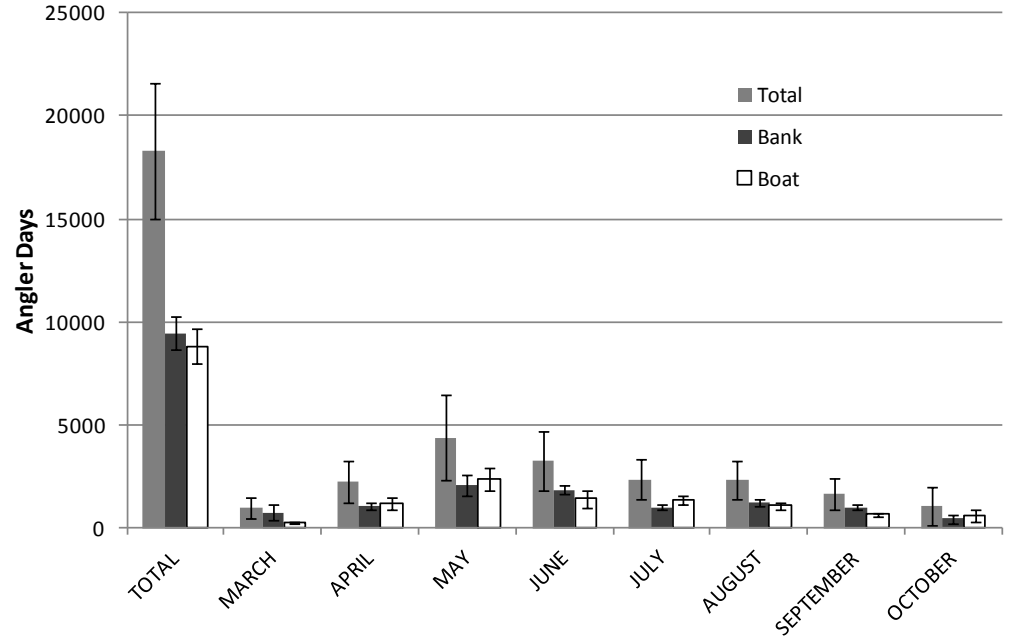

FIGURE 6. Estimated angler days (± 1 SE). North Platte River, Gray Reef Dam to Robertson Road, March 15-October 31, 2009.

Spatial distribution of pressure

The trophy regulation area (upper 7.6 miles of river) received significantly more bank pressure than the remaining 31.8 miles combined ($Z = 5.17$, $P < 0.001$). Further, count maps revealed 98.2% of the pressure on the Gray Reef to Lusby reach occurs in a short 2.1 mile reach of public land from Gray Reef Dam to Pete's Draw, while the remaining 5.56 miles of the trophy area received very little bank angler use (Table 2). Spatially, bank angler pressure is positively correlated with the amount of accessable public lands in a reach. When pressure by reach is examined seasonally, a pattern is evident that is diluted by the GR-UL reach in the total pressure estimates. All reaches with the exception of GR-UL, show a bi-modal distribution of pressure with peaks in May and again in September (Figure 7).

TABLE 2. Distribution of bank angler pressure by river section. North Platte River, Gray Reef Dam to Robertson Road Bridge, March 15 – October 31, 2009.

Section	Hours	Miles	% Public	Hours/mile
GR-PD	18,659	2.0	100	9,265
PD-UL	346	5.6	0	62
UL-GB	3,378	5.5	65	613
GB-LS	7,421	11.2	68	662
LS-BB	3,152	6.1	21	517
BB-RR	767	9.0	2	86
TOTAL	33,726	39.4	37	857

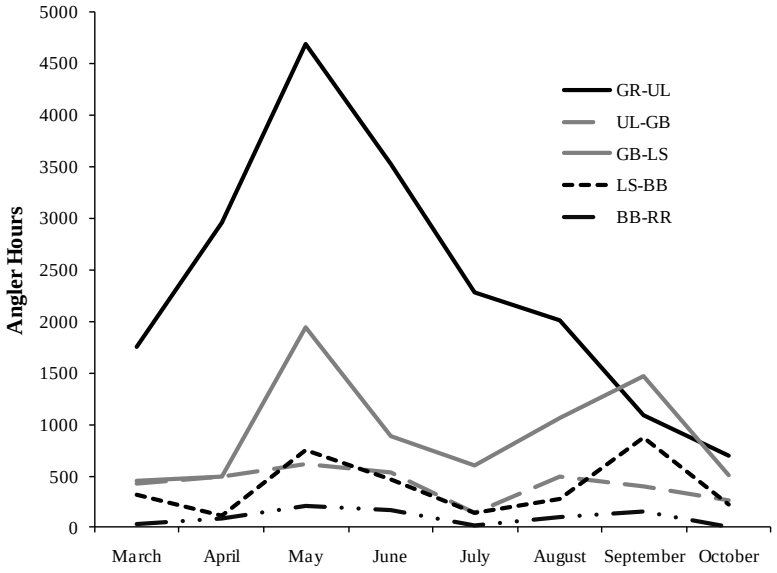

FIGURE 7. Shore angling hours by month and river reach. North Platte River, Gray Reef Dam to Robertson Road Bridge, March 15 – October 31, 2009.

Similar to bank angler pressure, the upper reach (GR-L) received significantly more boat angler pressure than the rest of the river combined ($Z = 6.76$, $P < 0.001$) (Table 3). Seasonal boat angler pressure on the upper reach follows a similar pattern to bank angler use. Boat angler pressure however, was more consistent throughout the season than bank angler pressure. The reaches downstream of the Sechrist boat ramp actually have a pattern of increasing pressure throughout the summer and into autumn (Figure 8).

TABLE 3. Distribution of boat angler pressure by river section. North Platte River, Gray Reef Dam to Robertson Road Bridge, March 15 – October 31, 2009.

Section	Number	Hours	Miles	Hours/mile
GR-L	472	31,734	8.5	3,723
L-GB	63	4,086	4.4	937
GB-S	147	8,737	11.0	798
S-BB	65	3,604	6.4	566
BB-RR	62	3,289	9.0	367
TOTAL	809	51,451	39.3	1,314

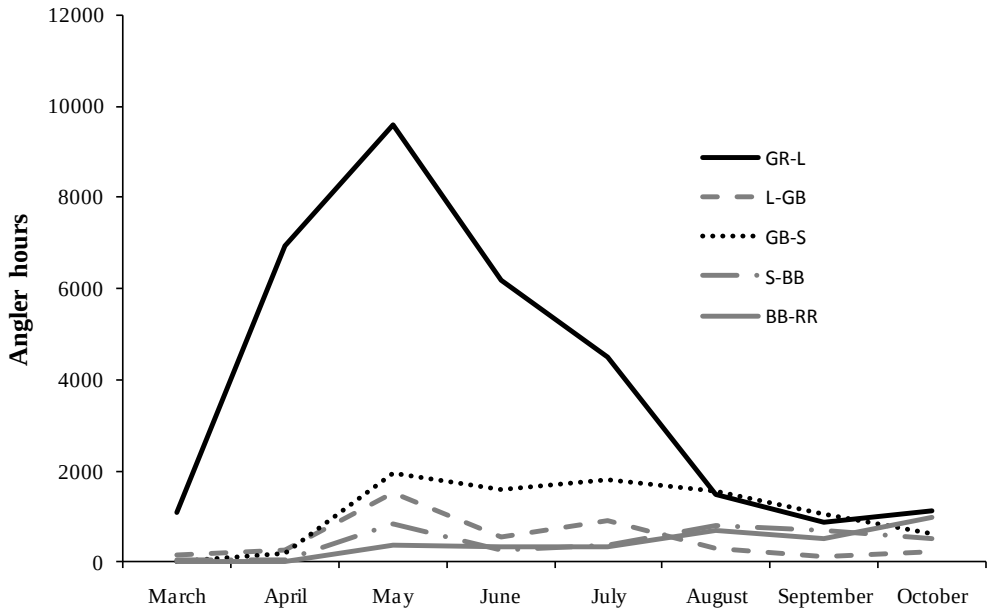

FIGURE 8. Boat angling hours by month and river reach. North Platte River, Gray Reef Dam to Robertson Road Bridge, March 15 – October 31, 2009.

Catch Rates and Harvest

The season long estimate for catch rate of all species by all anglers was 0.93 fish per hour. Catch rates were highest in March and lowest in June (Table 4). Boat anglers had higher mean individual catch rates than bank anglers ($t = 5.03$, $P < 0.001$). Further, guided boat anglers had significantly higher catch rates than un-guided boat anglers (t=5.28, $P < 0.001$). Mean catch rate between bank and unguided boat anglers did not differ significantly (t=0.03, $P = 0.974$; Figure 9).

TABLE 4. WyoCreel generated catch rate estimates (SE) by month and trip type. North Platte River, Gray Reef Dam to Robertson Road Bridge, March 15 – October 31, 2009. Catch rates are reflected in trout per hour.

Month	All	Bank	Boat
March	1.15 (0.55)	0.91 (0.63)	1.67 (0.97)
April	0.89 (0.26)	0.83 (0.33)	0.92 (0.35)
May	1.05 (0.31)	0.55 (0.21)	1.34 (0.44)
June	0.73 (0.21)	0.44 (0.17)	0.90 (0.35)
July	0.93 (0.20)	0.45 (0.13)	1.13 (0.29)
August	0.82 (0.19)	0.53 (0.08)	1.06 (0.36)
September	0.92 (0.19)	0.81 (0.21)	1.05 (0.30)
October	1.06 (0.06)	0.83 (0.43)	1.17 (0.77)
Season	0.93 (0.06)	0.63 (0.04)	1.12 (0.04)

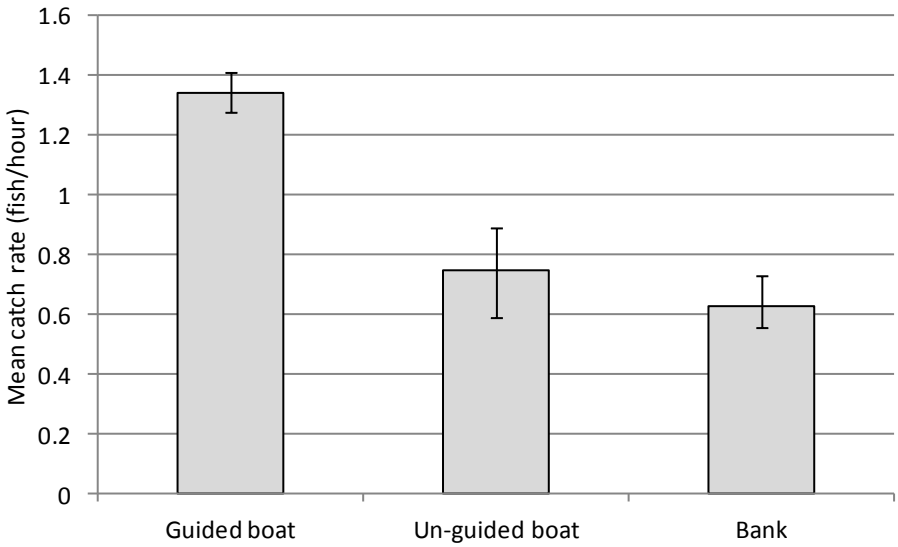

FIGURE 9. Mean individual catch rate (trout/hour) from raw interview data of anglers who reported fishing ≥ 1.0 hours. Error bars are bootstrap 95% confidence intervals. North Platte River, Gray Reef Dam to Robertson Road Bridge, March 15 – October 31, 2009.

The mean bank angler catch rate decreased with increasing distance from Gray Reef Dam, although not significantly (one-way ANOVA, $F_{3,646}$=0.28, P = 0.84). The highest bank angler catch rate was at Gray Reef Dam (0.65 trout per hour, SD = 1.12). The lowest bank angler catch rate was in the Sechrist to Bessemer reach (0.54 trout per hour, SD = 0.64). Boat angler catch rate showed no discernible pattern but varied more widely among reaches than bank angler catch rates ($F_{4,714}$ = 1.21, P = 0.31). The highest boat angler catch rate was in the Government Bridge to Sechrist reach (1.11 trout per hour, SD = 0.72) with the lowest catch rate in the Lusby to Government Bridge reach (0.65 trout per hour, SD = 0.63).

The proportion of anglers catching at least 0.5 trout per hour varied among angler group. Bank angler $PAS_{0.5}$ was 0.42 (N=646). Unguided boat angler $PAS_{0.5}$ was 0.47 (N=382), while guided boat anglers $PAS_{0.5}$ was 0.86 (N=375). Statistically, there is little difference in the $PAS_{0.5}$ among bank and unguided boat anglers (Z = 1.81, P = 0.07) while guided boat anglers had significantly higher $PAS_{0.5}$ than unguided anglers (Z = 12.38, P < 0.001).

The estimated catch of all trout by all anglers was 79,036 (SE=6,792). Boat anglers accounted for 73.1% of the total trout catch. Rainbow trout were by far the most common species caught (97.7%), followed distantly by SRC (1.7%) and BNT (0.6%; Figure 10).

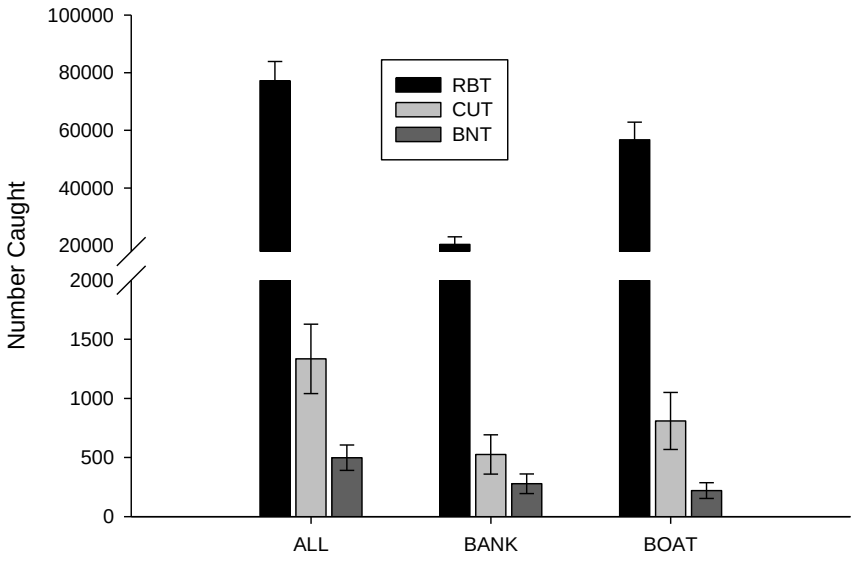

FIGURE 10. Estimated catch of various trout species (± 1 SE) by bank, boat and all anglers combined. North Platte River, Gray Reef Dam to Robertson Road Bridge, March 15 – October 31, 2009.

An estimated 1,350 (SE = 264) trout were harvested for an overall harvest rate of 1.7%. Harvest estimates by species were: RBT 1,287 (SE=254), SRC 31 (SE = 23) and BNT 32 (SE = 24). Interview data shows bank anglers accounted for the vast majority of harvest (83.4%). Bait anglers accounted for 46.7% of the total harvest even though they represented only 8.9% of the

angler days. Furthermore, residents accounted for 81.3% of the harvested fish while they only represented 38.3% of angler days.

Based on raw interview data, the majority of trout harvest (64.8%) occurred downstream of Government Bridge (Figure 11). The Sechrist to Bessemer reach had the highest percentage of total harvest (32.9%) followed closely by the Government Bridge to Sechrist reach (31.9%). The estimated harvest below Bessemer Bend Bridge (the one reach managed under statewide regulations of 6 per day, 1 over 20 in) had no estimated harvest. It should be noted however that due to the lack of public bank access in this reach, there were very few angler interviews (*N*=9).

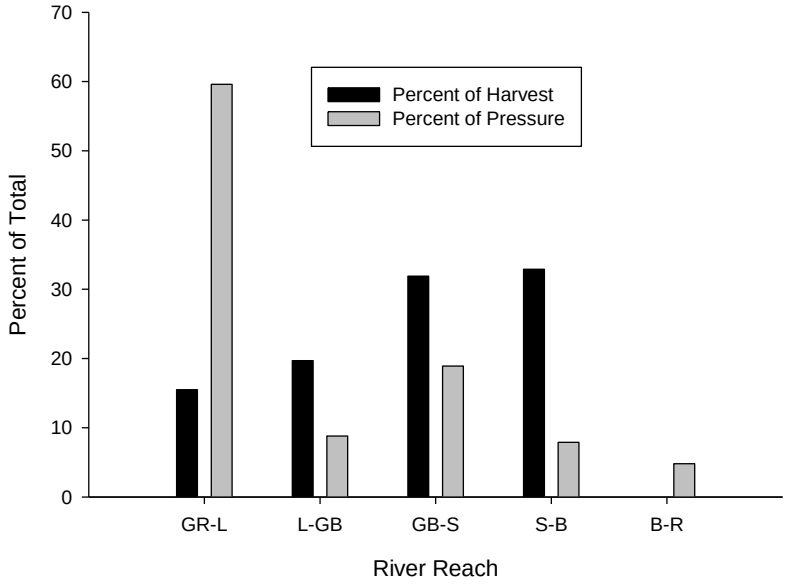

FIGURE 11. Percentages of total harvest and pressure by river reach. North Platte River, Gray Reef Dam to Robertson Road Bridge, March 15 – October 31, 2009.

Comparison with historic estimates

The demographics of Gray Reef anglers have changed significantly since 1995 (Figure 12). The proportion of non-resident anglers has increased from 22.6% of all anglers in 1995, to 61.7% in 2009. The increase in non-resident anglers is significant among all possible combinations of years ($P < 0.001$).

Angling methods have similarly undergone large changes over time. In 1973, fly anglers represented 12% of total anglers, with bait anglers being the majority at 69%. Most recently, fly anglers were the majority at 82.8%, with bait anglers being the minority at 9.1%. Interestingly, the lure fishing constituency has remained fairly constant over the 36 year period, fluctuating between a high of 14.9% in 1995 to a low of 5% in 1973 (Figure 13).

Similar to the pattern in fly angling, the number of boat anglers has increased dramatically since 1973 and most notably during the eight-year period between 2001 and 2009 (Figure 14). Compared to 1995, the number of boat anglers has increased significantly ($Z = 3.54$, $P < 0.001$). Conversely, the number of bank anglers has significantly declined ($Z = 2.05$, $P = 0.017$).

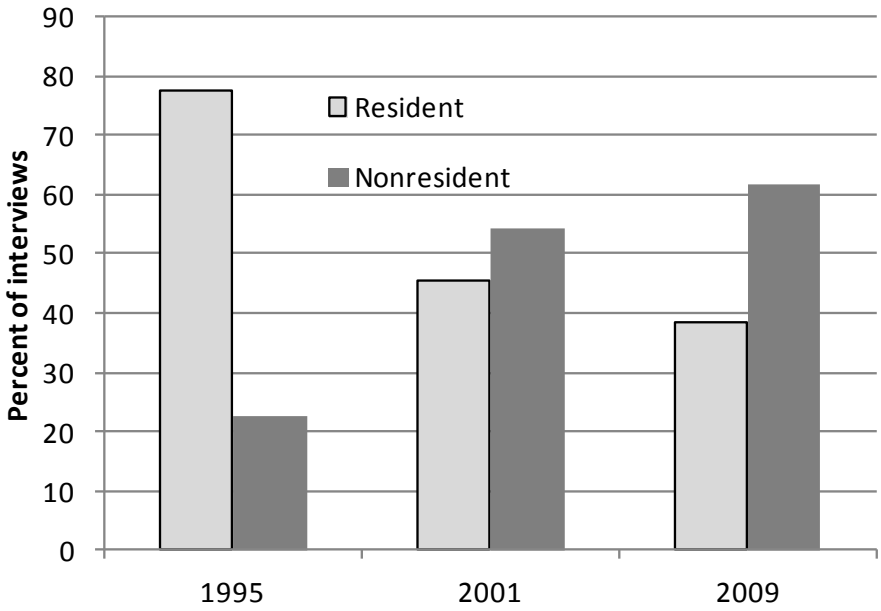

FIGURE 12. Percent of anglers fishing the Gray Reef tailwater who are residents or nonresidents, 1995 – 2009 (no data available for 1973).

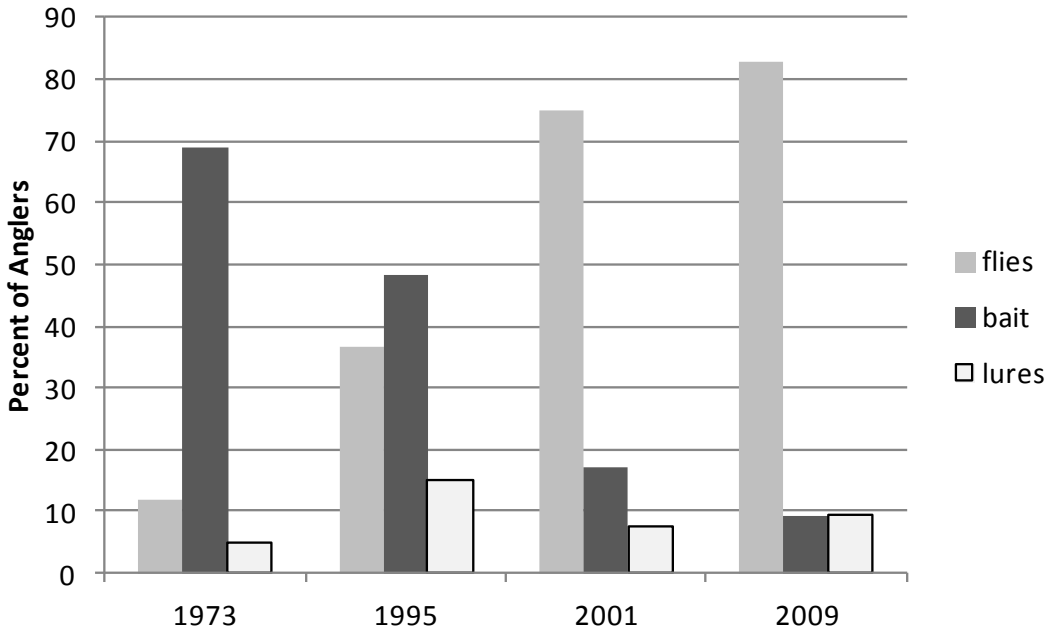

FIGURE 13. Terminal tackle use by anglers fishing the Gray Reef tailwater, 1973 – 2009.

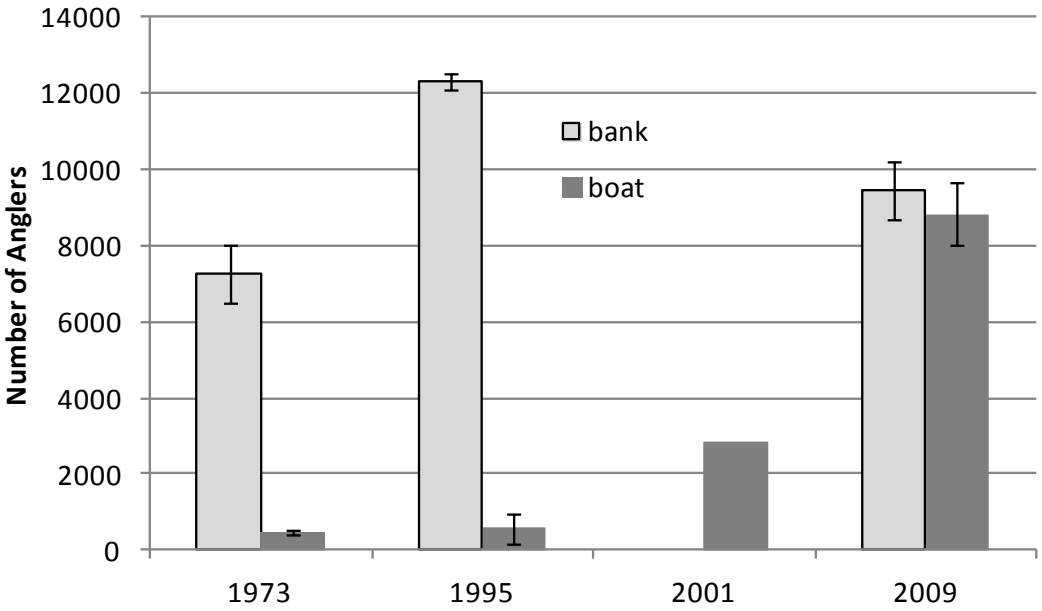

FIGURE 14. Estimated number of bank and boat anglers (± 1 SE) fishing the Gray Reef tailwater, 1973 – 2009. Bank anglers were not enumerated in the 2001 survey.

The only direct comparisons in total angler numbers and pressure could be made between 1995 and 2009 because the 1973 survey ended in the "area of the Bessemer narrows" while the 2001 survey enumerated only boat anglers using total census with cameras. The estimated number of anglers (April 1 – October 31) did not differ significantly between 1995 (14,754 anglers, SE = 1,956) and 2009 (17,324 anglers, SE = 3258) ($Z = 0.69$, $P = 0.22$) (Figure 15). There was, however, a significant increase in hours fished between 1995 (34,730 hours, SE = 2,900) and 2009 (80,881 hours, SE = 6,923) ($Z = 7.1$, $P < 0.001$; Figure 16).

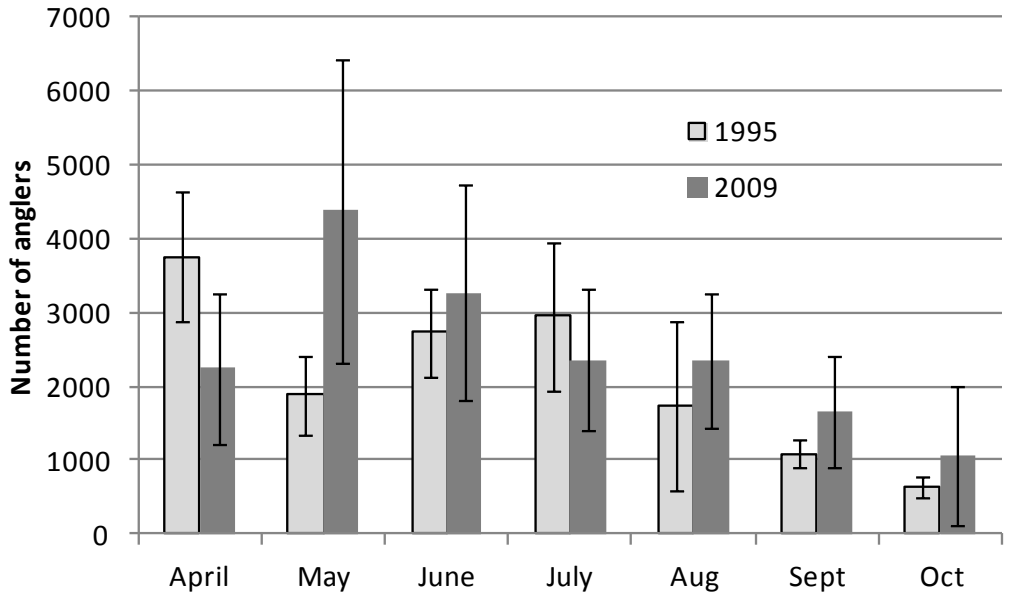

FIGURE 15. Estimated number of anglers fishing the Gray Reef tailwater by month (± 1 SE) in 1995 and 2009.

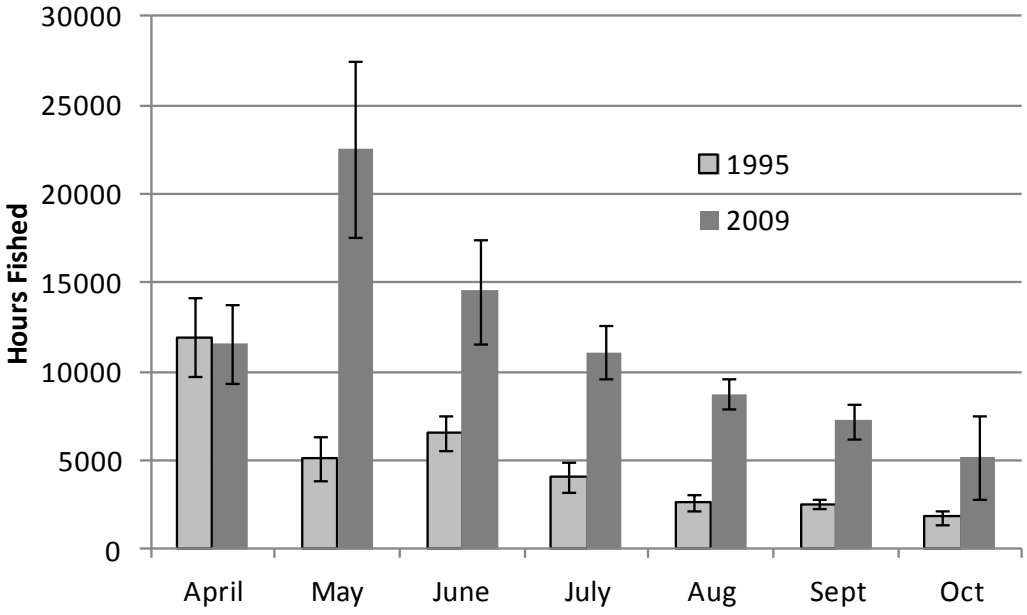

FIGURE 16. Estimated hours fished (± 1 SE) by month in 1995 and 2009. North Platte River, Gray Reef Dam to Robertson Road Bridge.

Mean catch rate for all anglers combined has increased significantly since 1995 ($F_{2,2293}$ =54.15, $P < 0.001$; Figure 17). Compared with 1995, boat angler catch rate was significantly greater in both 2001 and 2009 ($F_{2,986} = 23.62$, $P < 0.001$), while no significant difference was noted between 2001 and 2009 ($P = 0.12$). Similarly, there were significant differences in bank angler catch rate between years ($F_{2,1918} = 26.16$, $P < 0.001$) with both 2001 and 2009 being significantly greater than the bank angler catch rate in 1995, but with 2009 bank angler catch rate being significantly lower than 2001 ($P = 0.06$).

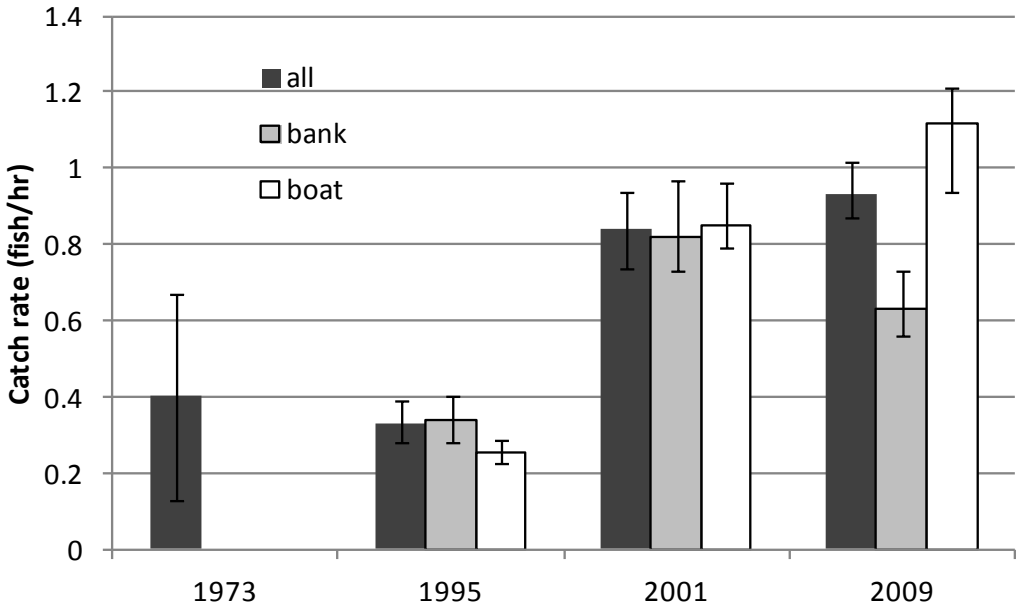

FIGURE 17. Angler catch rates on the Gray Reef tailwater, 1973 – 2009.

Since 1995, at least 40% of anglers had individual catch rates of at least 0.5 fish per hour (Figure 18). The largest single increase in $PAS_{0.5}$ was among boat anglers from 2001 to 2009 with a significant increase from 0.534 to 0.669 ($Z = 3.03$, $P = 0.002$). There was no significant difference in bank angler $PAS_{0.5}$ between 2001 and 2009 ($Z = 1.63$, $P = 0.103$).

Total trout catch has increased substantially since the first estimate in 1973, while trout harvest has declined (Figure 19). Nearly 66,000 more trout were caught from April 1 to October 31, 2009 than during the same interval in 1995. Even with drastically increased catch, the total number harvested declined significantly between 1995 and 2009 ($Z = 1.33$, $P = 0.08$). Comparisons could not be made with 1973 (no SE) or 2001 (no estimates of catch or harvest).

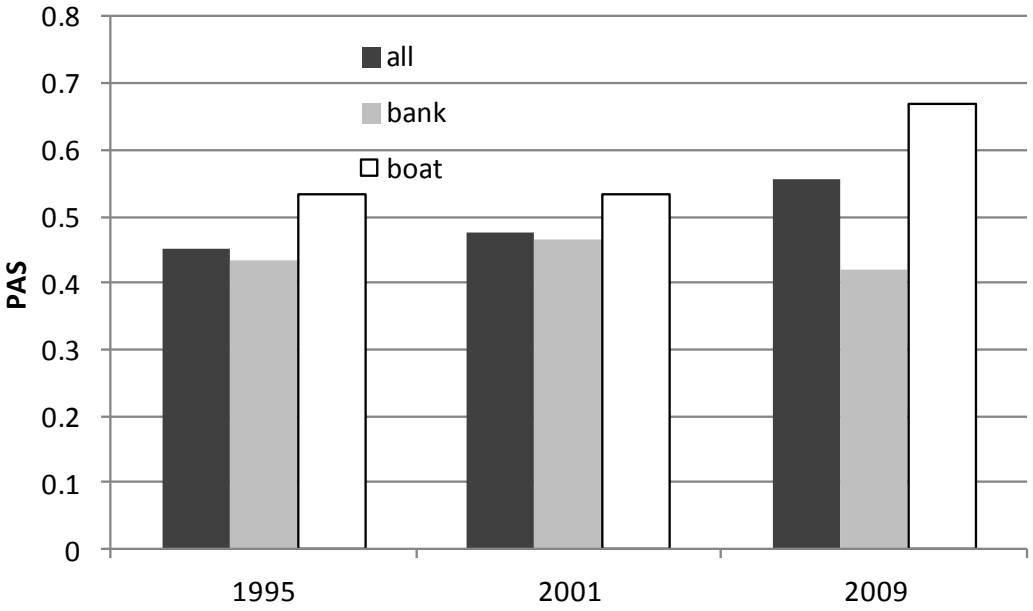

FIGURE 18. Proportional angling success calculated from interviews of anglers reporting fishing for at least one hour on the Gray Reef tailwater.

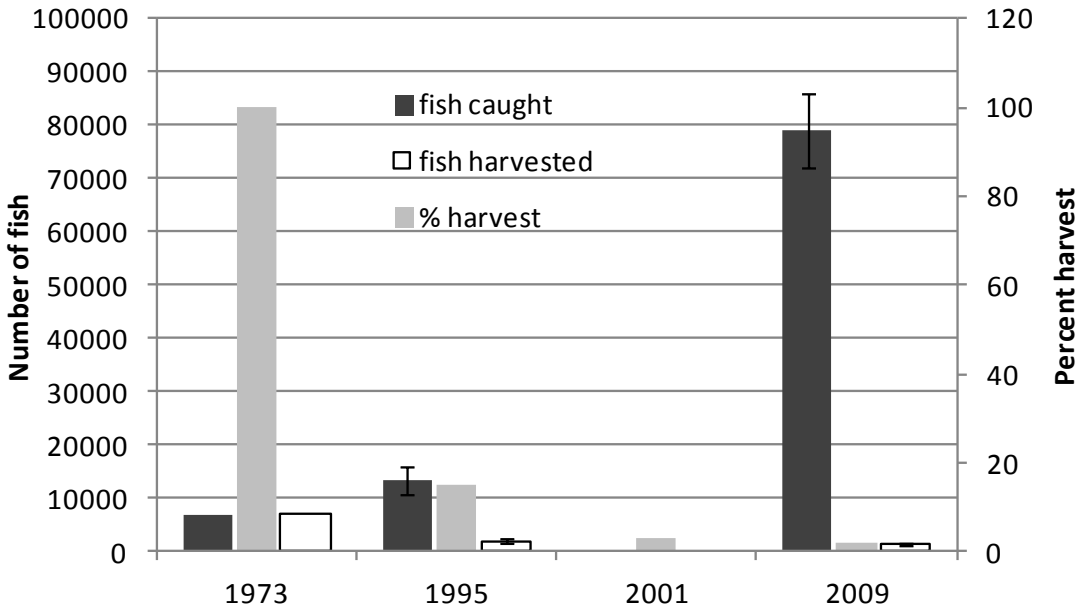

FIGURE 19. Estimates of April 1 – October 31 catch and harvest of trout from the Gray Reef tailwater. Error bars are ± 1 SE where available.

Discussion

Angler pressure in 2009 was the highest ever measured on the Gray Reef tailwater. Interestingly, the increased pressure is not a function of increased anglers, rather a significant increase in the length of an angler day since 1995. This is largely explained by a shift in the type of anglers fishing this reach. There are far fewer of what Peterson and McMillan (1973) called the "casual, after work fisherman", referring to local anglers with typical trip lengths of less than 2.5 hours. In 1973, these anglers represented at least 88% of the total angler days. By 1995, more non-residents were being drawn to the river and the percentage of anglers fitting the "casual" designation had fallen to around 40% based on raw interview data. In 2009, these anglers represented around 9% of the total anglers with non-residents comprising nearly 62% of all anglers. As residents are replaced with non-residents, angler pressure increases due to the significantly longer length of a complete trip by non-residents versus residents.

Anglers are increasingly more likely to be fly anglers. In 1973, fly anglers accounted for 12% of the use. By 1995, the proportion of fly anglers had increased to 29%. By 2001, the percentage of fly anglers increased to 75% and finally to 80% in 2009. The special regulation enacted in 1998 on the upper eight miles of river which restricted anglers to artificial flies and lures likely explains some of the shift to flies from bait, but the shift to flyfishing is seen throughout the entire 39 mile reach. The most likely explanation is that the demographics of Gray Reef fishermen has changed from "casual after work" anglers to "serious enough to drive five hours" anglers, the latter of which tend to be exclusively fly anglers.

Similar to the pattern in fly fishing, anglers are increasingly float-fishing the river. In 1973, a mere 6% of anglers floated the river. By 1995, boat anglers had increased to 19% of all anglers upstream of Lusby, while downstream of Lusby the percentage of boat anglers remained at 6%. By 2001, the number of boat anglers had increased substantially from 577 in 1995 to 2,827 in 2001, an increase of nearly 500%. The number of boat anglers continued to increase with an estimated 8,836 in 2009, an increase of 313% over 2001 and 1,500% over the 1973 – 1995 numbers.

The proliferation of guides on the river has certainly driven many of the observed changes in angler demographics. While the number of guided angler days has not been measured prior to this survey, there is ample evidence that angler use of the river has become increasingly commercialized. Prior to 1998, there were no businesses specializing in guided fishing trips on the river (Al Conder, personal communication). From 1983 to 1994, there was only one fly shop in Casper which did not offer trips. A second fly shop opened in 1994, and while they did not specifically offer guided trips, they would occasionally take out anglers. The first guide service opened in 1998 at Alcova. The proprietor conducted an extensive marketing campaign which coincided with the increasing popularity of the internet and essentially "put Gray Reef on the map" (Al Conder, personal communication). A quick internet search for "Gray Reef fishing guides" in March 2011, turned up 23 individual guide services offering float trips on the Gray Reef reach. Cross referencing with the Bureau of Land Management's list of permitted outfitters, shows nine of the 23 guide services are not permitted, while the BLM list turns up an additional 13 outfitters that were not found online. This brings the total to at least 36 guide services offering trips on the Gray Reef tailwater. To put this in perspective, the same internet

searches yielded 11 for the immensely popular Bighorn River in Montana and six for the Green River in Utah.

Interview data showed that the guided trips were all flyfishing boat trips. From raw interview data, guided boat trips represented 47% of the boat anglers and 28% of all anglers. While not estimated in WyoCreel, the percentage of total boat pressure that is guided is higher than 47% due to guided boat anglers having significantly longer trips (7.30 hrs, SD = 1.77) than unguided boat anglers (4.67 hrs, SD = 2.04) (t = 18.93, $P < 0.001$).

The influence of guided trips is apparent in catch rates. For example, the 1995 fish population at the Gray Reef station was 1,241 fish per mile and catch rates were 0.33 fish per hour. In 2000, the estimated population at Gray Reef was 4,020 fish per mile with angler catch rate in 2001 of 0.84 fish per hour. In 2009, however, the population was considerably lower than 2001 at Gray Reef (1,224 fish per mile) yet catch rate was higher (0.93 fish per hour). With guided trips having significantly higher catch rates than either unguided boat or shore anglers, and guided trips representing 28% of all anglers, it is apparent that the inclusion of guided trip data significantly influences the mean, and likely portrays unrealistic conditions for the majority of anglers.

Gray Reef anglers are increasingly less likely to harvest fish. Forty-two of 1,104 completed trip anglers (3.8%) reporting catching at least one fish, actually harvested fish. If only the river below the upper boundary of Lusby is considered (where it would be legal to harvest at least the first fish caught) 33 of 380 anglers (8.6%) harvested at least one fish. Of the 33 complete trip anglers who harvested fish, nine harvested a limit and one harvested more than the limit. Of the 23 remaining anglers who did not harvest a limit, 17 reported releasing fish. In 1995, 67 of 342 completed trip anglers (19.6%) who caught at least one fish harvested fish. In 2001, 32 of 484 (6.6%) harvested fish.

The average number of fish per mile between the 2009 Gray Reef and Bessemer electrofishing stations was 1,424 trout per mile (SE = 102). With 39 miles in the reach the estimated population from Gray Reef Dam to Robertson Road bridge is 55,500 trout $\geq$ 6.0 inches. The estimated harvest of 1,350 trout represents a March – October exploitation rate of 2.4%.

Much higher levels of exploitation are needed to negatively impact a wild salmonid population. In Wisconsin, a wild BNT fishery was stable at 18% exploitation (Toshner and Manz 2008). Bull trout *Salvelinus confluentus*, a species with much lower reproductive potential than RBT were not significantly impacted at levels below 28% (Post et al. 2003). Modeling on the sustainability of wild RBT populations in British Columbia lakes showed optimal exploitation rates (maximum sustainable yield) at 33% in low productivity environments and 56% in high productivity environments. Further, stock collapse was not imminent until exploitation approached 83% in low productivity waters while stock collapse due to angler harvest was not attainable in high productivity lakes (Cox and Walters 2002).

With an estimated 77,687 fish released, hooking mortality of released fish is likely more significant than actual harvest. A review of hooking mortality literature compiled by Taylor and Wright (1992) found hooking mortality in salmonids ranging from 3% to 50%, depending on species, and terminal tackle type. Schisler and Bergerson (1996) developed a mortality model for rainbow trout incorporating terminal tackle, temperature, where the fish is hooked, leader cut or hook removed, length of time the fish was played, length of time the fish was held out of water, bleeding intensity and length of fish. Using some preliminary data gathered while observing anglers in 2009 to estimate fighting and handling time, along with thermograph data, a

rough estimate of 2,500 fish were lost to hooking mortality. This should be considered a very conservative estimate as hooking and bleeding severity was assumed to be low for all fish. Nevertheless, the conservative mortality estimate exceeds harvest by a factor of two. More in-depth literature review and data collection on hooking and handling time and hooking and bleeding severity is needed. Given the estimated number of fish caught exceeds the estimated number present it is apparent many fish are caught multiple times, a suggestion backed by observations of multiple hook scars on a large proportion of Gray Reef trout captured while electrofishing. Individual mortality rates would have to be adjusted upwards to reflect the increased mortality risk associated with multiple hooking.

At this point, no regulation changes are needed. In fact, the current regulations are unnecessarily restrictive. Post et al. (2003) observed the byproduct of trophy regulations is that the majority of the sustainable harvest is discarded (through hooking mortality) and that such policies should be carefully scrutinized based on the "waste" of the resource they were originally designed to protect. Based on interview data, if the Lusby to Bessemer reach was managed under the statewide creel limit of 6 trout, assuming anglers who caught more than three trout would have harvested them, total harvest would have increased by 185% to an estimated 2,500 fish. The increased harvest would still likely be less than actual hooking mortality by catch and release anglers. However, restrictive regulations are socially desirable to the majority of Gray Reef anglers and relaxing limits would be met with considerable angst and resentment by the flyfishing community.

Recommendations

- Retain the current regulation framework. The "trophy" regulation on the upper seven miles is popular with the majority of anglers fishing that reach. The somewhat relaxed regulation from Lusby to Bessemer Bend Bridge provides opportunity for people who wish to harvest a few fish, yet seems to be restrictive enough to be accepted by the catch and release only contingent. Finally, retaining the six fish limit below Bessemer Bend provides a place where anglers who do like to harvest fish can go, and where harvest is sustainable under current levels of pressure.
- Set the management goal of angler $PAS_{0.5}$ (excluding guide boats) at ≥ 0.50. The inclusion of guide boats only serves to inflate measured catch rates and in some respects means that current economic conditions may exude some influence on catch statistics. With guided trips factored out, angler $PAS_{0.5}$ is approaching 0.45. With the depressed population in 2009, and the fact that anglers seem to be getting better at catching fish, a $PAS_{0.5} = 0.50$ should be obtainable with modest increases in standing stock.
- Collect spot creel data in even years to correspond with population sampling. Developing a relationship between $PAS_{0.5}$ and number per mile will allow for the refinement of current population goals to be more meaningful in terms of angler success. If such a relationship exists, the population goal should be set at the minimum level which maintains angler $PAS_{0.5} = 0.50$. Data should be collected April through June as this is when the majority of pressure occurs and typically represents the highest catch rates for unguided anglers. As was done in 2009, it should be recorded whether anglers are guided or not.

- The fishery should continue to be managed under the "wild" concept with a few exceptions. When spring flows have not been conducive to natural reproduction and it is likely that the population will dip below management goals, stocking should be employed to buffer the effects of a failed year-class. Obviously the current fish request framework is not conducive to such practices. Fish will likely have to be diverted from existing requests (such as the river below Casper) along with any fish declared "extras".
- Future programmed creel surveys should consider the use of creel cards for increasing completed trip interviews.

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