

North Fork Shoshone River Programmed Creel Survey 2008

Jason C. Burckhardt, Fisheries Biologist, Wyoming Game and Fish Department, 2820 State Highway 120, Cody, WY 82414

Abstract

A programmed creel survey was conducted on publicly accessible portions of the North Fork Shoshone River from April 15 to October 31, 2008. An estimated 6,434 anglers fished for 20,943 hours during the survey, a reduction from 10,800 anglers (40% reduction) and 21,742 hours (4% reduction) in 1991. Unusually turbid water and activities associated with a major wildfire in the North Fork Shoshone River drainage likely affected angling pressure.

Six species of trout, mountain whitefish and suckers were reported in the catch. Fish species caught by anglers generally reflected species composition from electrofishing surveys. Rainbow trout and rainbow-cutthroat trout hybrids were most frequently caught. Anglers caught 0.82 fish per hour, 80% of anglers caught 3 or more fish, and less than one percent of anglers did not catch any fish. Only 15.8% of fish caught were harvested and 73% of anglers did not harvest any fish.

Angler demographics have shifted substantially since the 1991 creel survey. More nonresident anglers fished the North Fork Shoshone River than resident anglers during 2008. Anglers from 45 states, the District of Columbia and three foreign countries were interviewed. Flies were the terminal tackle of choice with only 32% of anglers using bait (down from 60% in 1991).

Introduction

The North Fork Shoshone River (NFSR) is a mountain stream of about 49 mi long that confluences with Buffalo Bill Reservoir about 15 mi west of Cody, WY. The NFSR is a blue ribbon trout stream with trout biomass greater than 600 lb/mi and is one of the most popular fisheries in the Cody Fisheries Management Region (WGFD 2011).

The NFSR flows from the Absaroka Mountains with spectacular rugged mountain topography which provides a picturesque setting for angling. Theodore Roosevelt is said to have called the NFSR corridor “the most scenic 50 miles in America.” However, the highly erosive geologic nature of these mountains affects trout habitat and the NFSR quickly becomes turbid during rain events. The NFSR has a mean annual discharge of about 800 cfs and a snowmelt dominated hydrograph with peak flows typically reaching 4,000 cfs at USGS gage 06279940 (North Fork Shoshone River at Wapiti, WY) from late May through the month of June. Flows during the 2008 water year were substantially higher than mean flows of the 21 year period of record.

The NFSR's juxtaposition with Buffalo Bill Reservoir provides a productive sport fishery. The NFSR and tributaries provide spawning and nursery habitat for wild trout within the drainage and is the primary source of recruitment for Buffalo Bill Reservoir, which provides habitat for growth and maturation. Consequently, the NFSR supports trout populations that would otherwise not be possible in such a riverine environment. Each year, beginning in early spring, adult trout migrate from Buffalo Bill Reservoir to NFSR and tributaries to spawn. These trout typically remain in the NFSR until late summer or early fall, returning to Buffalo Bill Reservoir prior to the onset of winter.

The NFSR fishery is managed for native Yellowstone cutthroat trout (YCT) and wild rainbow trout (RBT). Hybridization between these two species is common within the drainage and these rainbow-cutthroat hybrids (RXC) are the most plentiful sportfish in the NFSR. Brown trout (BNT), brook trout (BKT) and lake trout (LAT) have also been introduced and become naturalized within the drainage. BNT and BKT persist at much lower densities than *Oncorhynchus* sp. in the NFSR and LAT are more typically found in Buffalo Bill Reservoir, but do venture into the NFSR. Native mountain whitefish (MWF) still persist in the NFSR and provide additional angling opportunities.

Stocking in the drainage first occurred in the early 1900s, with almost annual stocking occurring from 1933 to 1989 (Kent 1995). Approximately 17,900 catchable Snake River Cutthroat (SRC) were stocked annually from 1966 to 1980. In 1981 stocks were converted to YCT and in 1986 catchable plants were discontinued. The NFSR was also stocked annually from 1985 to 1989 with 100,000 fry/fingerling YCT in an effort to restore this native species. Stocking was discontinued in 1989 when the stocked YCT were found to contribute little to the fishery. Stocking in Buffalo Bill Reservoir was similar to that of the NFSR with a conversion of SRC to YCT in 1979. The reservoir was last stocked in 1995 and both the river and reservoir have been managed as wild fisheries since. Despite SRC being stocked in the NFSR basin until 1980, this variety of YCT has contributed little to natural recruitment and is seldom seen in the river or reservoir.

Fishing regulations have been instrumental in establishing and maintaining a wild trout fishery within the drainage. Both fishing closures and restrictive harvest regulations have been implemented on both the NFSR and Buffalo Bill Reservoir. Springs fishing closures began in the early 1950s to prevent excessive harvest of mature migrant trout as they move from the reservoir to NFSR tributaries to spawn. A spring closure on the NFSR drainage from Buffalo Bill Reservoir to Clearwater Creek was extended upstream to include Newton Creek when extensive use by spawning trout was found up to that point in the drainage (Kent 1984). Restrictive creel limits have also been used to conserve wild trout. Creel limits have become increasingly restrictive through time and are currently three trout, with no more than two cutthroats and no more than one shall exceed 18 in. The same regulation exists on Buffalo Bill Reservoir as they are the same fish that reside in the NFSR drainage.

Angler access to the NFSR is relatively easy with US Highway 14-16-20 paralleling it from Buffalo Bill Reservoir to Pahaska Teepee. The upper reaches can be accessed through the Shoshone National Forest (27.6 mi). Below the National Forest boundary, the NFSR flows primarily through private lands for 11.5 mi. The river through these lands can be accessed by boat, but bank fishing access requires permission from land owners. There are five public access areas below the Forest Service boundary including Livermore, Wapiti, River's Rest (Jim Creek), 6FU, and Trout Creek. Boat ramps are present at River's Rest (Jim Creek) and Gibbs Bridge, on Buffalo Bill State Park. Primitive launch sites are present on the Shoshone National Forest at

Pahaska, Eagle Creek, Mummy Cave, just upstream of the Elks Fork Creek confluence, and at the forest boundary.

Programmed creel surveys were conducted on the NFSR in 1991, 1979, and 1978. Ample spot creel data have been collected by the Cody Fisheries Management Crew and local game wardens since 1992.

The 2008 creel survey was conducted to address five primary objectives. The first objective was to determine how angling demographics and preferences have changed since the last programmed creel survey. Second, determine if angling pressure and harvest have significantly changed since the last programmed creel survey. Third, determine if anglers are harvesting enough fish to have population level impacts. Fourth, determine if these impacts may be affecting angler catch rates. Lastly to help formulate objectives related to angler catch rates.

Methods

A creel survey was conducted from April 15 through October 2008 on all publicly accessible portions of the North Fork Shoshone River between the 6KV Bridge (commonly referred to as Gibbs Bridge) and Pahaska Teepee (Figure 1). While angling does occur before and after this period and on private property along this section of the NFSR, the spatial and temporal extent of this survey encompasses most of the angling on the NFSR in a typical year. The sampling area was spatially stratified into three reaches based on angler access and location of seasonal fishing closures. The three sampling reaches were from Gibbs Bridge to the US Forest Service boundary (1.9 mi; Area 1), the US Forest Service boundary to Newton Creek (14.4 mi; Area 2), and Newton Creek to Pahaska Teepee (13.2 mi; Area 3).

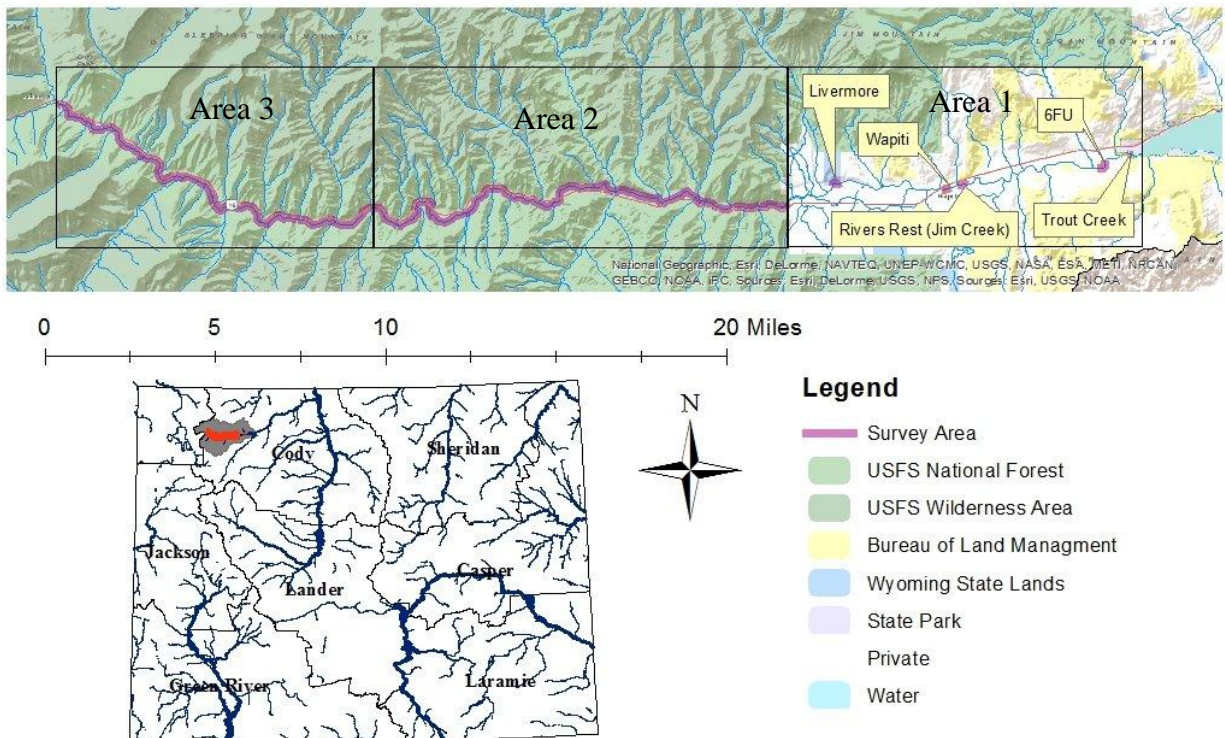


FIGURE 1. North Fork Shoshone River including locations of three sampling areas.

Angler counts

The creel survey angler count schedule was established based on a stratified two-stage sampling regime with systematic sampling at the second stage. The fishing day was the primary sampling unit and was stratified into week days, weekend days and holidays. The fishing day length was established as daylight hours which varied by month throughout the duration of the creel survey. Sample days within each strata were randomly selected. Four weekend days and six weekdays were sampled per month with three counts on each of the sampled days. The second stage of sampling was angler counts which were made at equally spaced intervals during the sample day. The time of the first count was randomly selected and the direction the creel clerk conducts the creel survey (upstream or downstream direction) was randomly selected. The creel program CREELCAL QBX-3.02 was used to generate the angler count schedule.

Survey period by river section varied because of spring fishing closures. One creel clerk conducted creel counts May through June on Area 3 (Newton Creek to Pahaska) the only area open to angling during that period. Two creel clerks conducted counts June through October on the entire survey area. In Area 1, creel counts were conducted by driving to the five public access areas: Livermore, Wapiti, River's Rest (Jim Creek), 6FU, and Trout Creek. In Areas 2 and 3, creel clerks drove along Highway 14-16-20 and through all open camping and day-use areas. When any vehicles that may have carried anglers were identified, creel clerks would proceed to the river on foot to identify anglers. Individual anglers observed fishing were counted. Identifying angler's vehicles was much easier than in prior creel surveys conducted on the NFSR as reconstruction of Highway 14-16-20 since the 1991 survey eliminated many of the side roads and pull offs that concealed vehicles during those surveys.

On days when angler counts were conducted, creel clerks described weather and NFSR water conditions, since these environmental factors likely play a role in the number of anglers fishing on a given day.

Angler interviews

Anglers were interviewed by creel clerks between counts and occasionally on days when counts were not conducted. When interviews were conducted on days that counts were not conducted, the interviews were associated with the closest day within that stratum (weekday or weekend day).

Creel clerks were instructed to be clear and concise when conducting interviews and be unbiased and consistent in their interview techniques. Clerks were provided with written instructions to help ensure consistency between interviews. During angler interviews, clerks recorded time of interview, the number of hours fished, and whether the angler had finished fishing for the day. The mode of angling (from bank or boat), number of rods used, terminal tackle used (flies, lures, bait or all possible combinations of tackle), species preference, angler residence, and license type was recorded. Anglers were asked to report the number of fish caught and kept or released by species and how satisfied they were with their angling experience on a five point scale (from very satisfied to very dissatisfied). To determine the support for current or future YCT conservation efforts in the drainage, anglers were asked: "Do you support regulations or management actions to conserve our native Yellowstone cutthroat trout?"

Anglers who had not completed angling for the day were given a self addressed postage paid postcard where they could report a number of attributes necessary to generate a completed trip interview and return it after they had finished. Attributes included on the self-report card included where they fished, time spent fishing, the species they caught and kept or released, terminal tackle used, satisfaction with their angling experience, their support for Yellowstone cutthroat trout management and any additional comments they wished to include. Creel clerks

dated and numbered the self report cards so cards received could be cross referenced to other interview data collected at the time of angler contact. When anglers that had harvested fish were encountered, species and length of fish harvested were recorded.

Angling pressure estimates

Angler estimates were calculated for all strata using Statistical Method 1 of Wyocreel 1.63 (Wyoming Game and Fish Department 2002) for a standard uniform-probability creel survey using average completed trip length for each strata to determine probability of detection during creel counts. Self-report cards were used to increase the number of completed trip interviews. Estimates were calculated for each of the three areas from July through October. All estimates were then pooled for an overall estimate of July through October. Area 3 was the only area open to fishing from April through June so estimates for Area 3 April-June were calculated separately. Per-mile estimates were calculated using publicly accessible river lengths measured on 1:100,000 scale hydrography using Arcmap 9.3.1 (ESRI 2010). The number of anglers was back-calculated using the probability of detecting anglers given the average length of angling day from completed trip interviews.

Spot creel surveys

Spot Creel surveys have been conducted on the NFSR by the Cody Fisheries Management Crew and local game wardens since the 1970s. Data collected during these spot creel surveys include amount of time angling, residence of the angler, license type held by the angler, terminal tackle used, type of trip (bank or boat) and number of fish caught and/or harvested segregated by species. While these data cannot be used to generate angling pressure estimates, they can be used to determine catch and harvest rates and other angler demographics.

Trout population estimates

Population estimates calculated on two reaches of the NFSR in 2006 and 2008 can be found in TABLE 6 and TABLE 7. Data were collected for four-pass mark recapture population estimates over four consecutive days using two rafts with fixed electrodes for each reach. Population estimates were calculated using the model M_t in Capture (White et al. 1982).

Data needed for trout population estimates within creel survey Area 1 were collected August 11-14, 2008 at the historic 3.7 mile-long electrofishing station located between Rivers Rest and the 6FU fishing area,. Data needed for trout population estimates within creel survey Area 2 were collected July 26-28, 2006 at the 6.3 mile-long historic electrofishing station located between Mummy Cave and Elks Fork.

At each site, data were collected over four consecutive days using raft-mounted electrofishing gear. Two rafts with one netter in each boat were used. Trout captured were given a unique mark on each sampling day for identification on subsequent passes. Population estimates were calculated for each species using the model M_t in CAPTURE (White et al. 1982). Due to the mobile and dynamic nature of these populations, these population estimates should only be considered a snapshot of the trout populations during the angling season. Trout population estimates were made using similar methods for Area 1 in 2000 and 2003, and are reported here to illustrate the variability of the trout populations over time.

Statistical analysis

Statistical analyses were conducted using the appropriate statistical tools in SigmaPlot11.0 (Systat Software Inc. 2008). Individual catch rates were used to calculate proportional angler success (PAS; Bailey 2007) for anglers that fished for at least one hour. The

parameter of interest was $PAS_{0.5}$, which is based on the percentage of anglers reporting a catch rate of ≥ 0.5 fish per hour.

RESULTS

“Instantaneous” creel counts took an average of 23 min in Areas 1 and 2 (range 13 to 34 and 22 to 23 min respectively) and 25 min in Area 3 (range 15 to 43 min). Count times were affected by highway construction and highway congestion associated with firefighting activities related to the Gunbarrel Fire. These count times are much lower than the average count time of two hours 1991 and 3.5 hours in 1978 and 1979.

A total of 1,416 anglers were counted in 2008. The total number of anglers counted was similar to the 1,446 anglers counted during the 1991 creel survey. An average of 6.6 anglers was counted during each count period, which was a decrease from 11 per count in 1991. The number of anglers counted throughout the angling season was highly variable ranging from 0 to 89 per day. The highest angler counts occurred from the middle of July through August (FIGURE 2). Of the anglers counted, only 3% (42) were boat anglers. A total of 1,163 anglers were interviewed, of which only 24 were boat anglers.

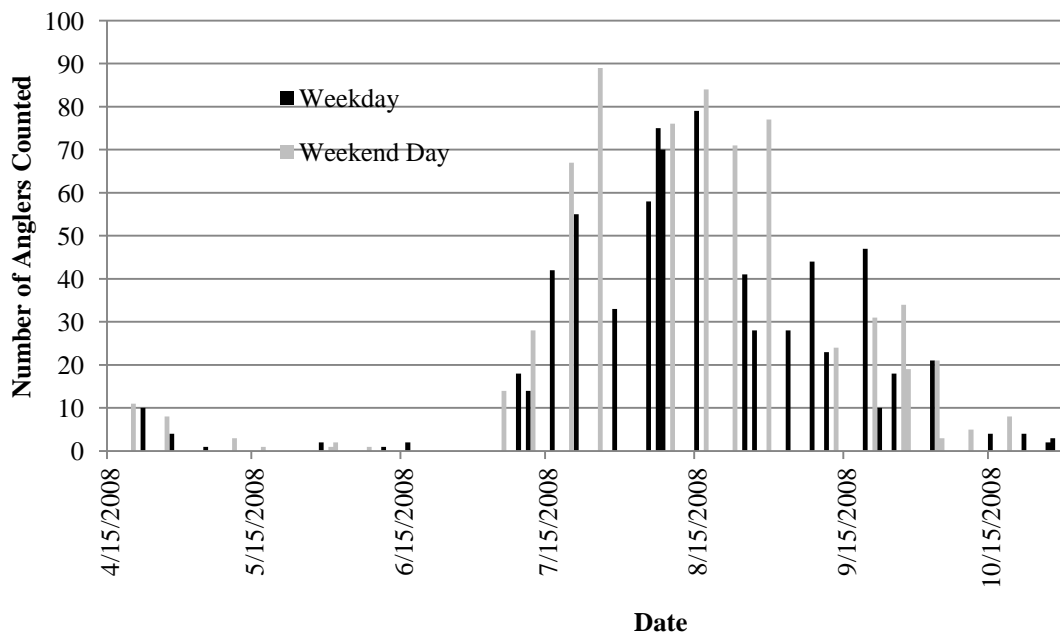


FIGURE 2. Angler counts conducted on the North Fork Shoshone River April 15—October 31, 2008.

Angler Demographics

More than half (53%) of the anglers interviewed were nonresidents (TABLE 1). Anglers from 45 states, the District of Columbia, and three foreign countries (Canada, Spain and New Zealand) were interviewed. Anglers from California comprised the largest nonresident constituent, followed by Colorado, Montana and Texas. Of resident anglers, Park County comprised a majority (85%) of the anglers interviewed. Anglers from 14 of Wyoming's 23 counties were interviewed. Resident annual licenses were the most common licenses (37%) held by anglers. Nonresident daily (28%) and nonresident annual (17%) licenses were the next most common licenses encountered.

TABLE 1. Reported residences of anglers surveyed during the 2008 North Fork Shoshone creel survey.

Wyoming Residence	Number of Anglers	Nonresident State or Country	Number of Anglers
Park County, WY	525	California	72
Bighorn County, WY	37	Colorado	59
Campbell County, WY	9	Montana	35
Laramie County, WY	7	Texas	34
Sheridan County, WY	7	Illinois	24
Albany County, WY	7	New York	24
Natrona County, WY	6	Pennsylvania	23
Teton County, WY	6	Florida	22
Washakie County, WY	4	Wisconsin	21
Fremont County, WY	3	Michigan	17
Sweetwater County, WY	2	Iowa	14
Crook County, WY	2	North Carolina	14
Platte County, WY	1	Washington	14
		Georgia	13
		Kansas	11
		Ohio	11
		Virginia	10
		Oklahoma	9
		Tennessee	9
		Massachusetts	8
		Nebraska	8
		Idaho	7
		South Carolina	7
		South Dakota	7
		Arizona	6
		Arkansas	6
		New Jersey	6
		Minnesota	5
		Oregon	5
		Alabama	4
		Hawaii	4
		Nevada	4
		West Virginia	4
		Canada	3
		Connecticut	3
		Indiana	3
		Maryland	3
		Utah	3
		Mississippi	2
		New Hampshire	2
		North Dakota	2
		Delaware	1
		Missouri	1
		New Mexico	1
		Rhode Island	1
		Washington DC	1
		Canada	3
		Spain	3
		New Zealand	1

Flies were the terminal tackle of choice with over half of the anglers fly fishing (Figure 3). Thirty-two percent of anglers were using bait alone or in combination with other tackle and 31% of anglers were using lures. Residents and nonresidents alike used a variety of tackle, but bait anglers were more commonly Wyoming residents. In contrast, 60% of anglers were using bait alone or in combination with other tackle and only 18% using flies in 1991.

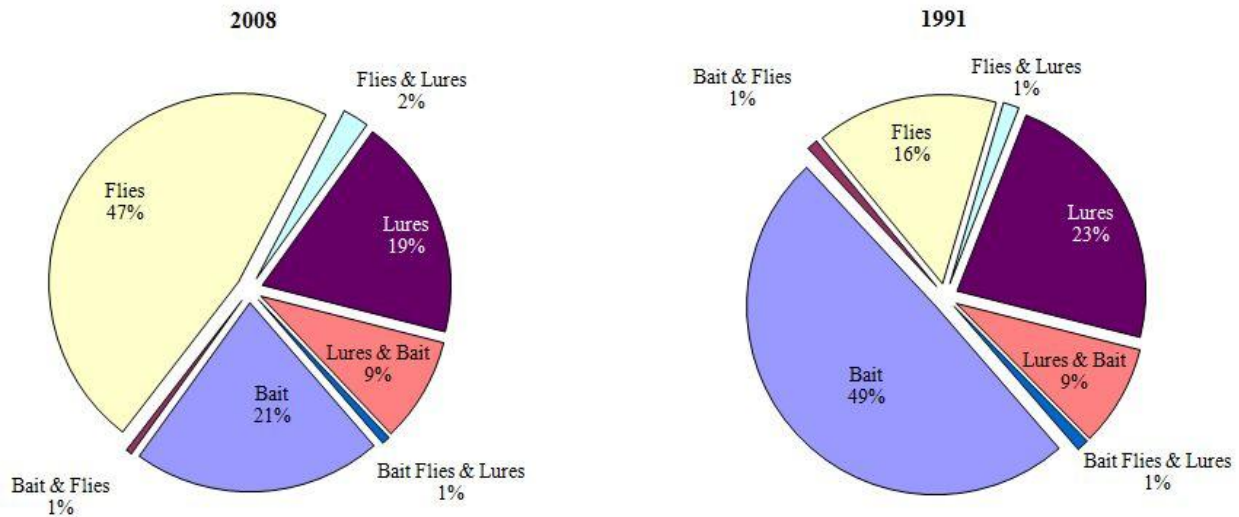


FIGURE 3. Proportion of anglers using various terminal tackle types during the 2008 and 1991 creel surveys on the North Fork Shoshone River.

Angler Preferences

Of the 1,163 anglers interviewed, 605 answered the question regarding satisfaction with their angling experience. A majority of anglers interviewed were either very satisfied (63%) or satisfied (26%) with their angling experience. There was no significant difference in number of fish caught between anglers that were very satisfied or satisfied versus those that were unsatisfied or very unsatisfied (two sample *t*-test; $P = 0.749$). Most of the anglers interviewed stated they had no preference for what they caught (42%) or preferred to catch trout (42%). Nine percent of anglers interviewed stated they preferred to catch YCT.

An overwhelming majority (86%) of the anglers interviewed were in support of regulations and conservation actions to protect YCT. Only 6% did not support YCT conservation measures and 8% were undecided. However, angler comments on self report cards suggest some tentativeness with regard to this question, and it would likely depend upon the type of conservation action being proposed.

Fishing Pressure

An estimated 6,434 anglers fished for 20,943 hours on the NFSR from mid April through October 2008 (FIGURE 4). This is significantly fewer anglers than the 10,800 anglers in 1991. However, angling pressure was not significantly different in (20,943 angling hours in 2008 versus 21,724 in 1991; two sample *t*-test, $P = 0.698$). Based on completed trip interviews, that average angling day was 4.5 hours. Area 2, from the US Forest Service boundary to Newton

Creek, had the highest fishing pressure with 2,791 anglers and 9,735 angling hours (43% of anglers and 46% of angling hours) though Area 3 was open for 2.5 more months during this survey. Area 3 had the next highest number of anglers (2,197; 34%) and angling hours 6,454; 31%). Area 1 had the lowest number of anglers (1,446) and angling hours (4,754), though it represented the highest density of anglers as the publicly accessible portions of this area only comprise 1.9 miles of the NFSR compared to the 14.4 and 13.2 miles of NFSR in areas 2 and 3 respectively.

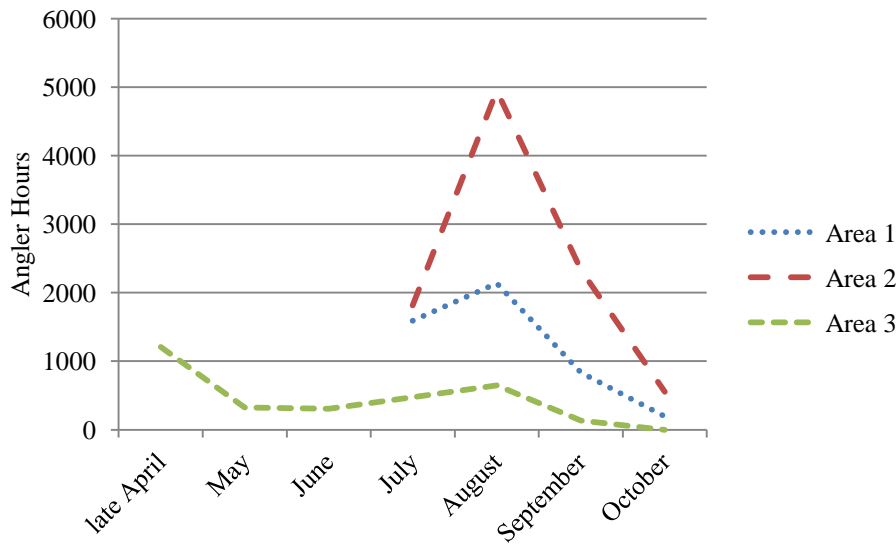


FIGURE 4. Angling hours by month and area, North Fork Shoshone River April 15—October 31, 2008.

Past creel surveys found July to be the most heavily fished month. However, in the 2008 survey, August was by far the most heavily fished month (36% of anglers) followed by July and September with 22% and 15% of anglers respectively.

Catch and harvest statistics

Six species of trout, mountain whitefish, and suckers were reported in the catch. Rainbow trout were the most commonly caught fish in the NFSR (49% of the catch), followed by MWF (17%), RXC (15%) and YSC (11%; TABLE 2). All species of gamefish were caught in each of the sampled sections, except BKT were not caught in Area 1 (TABLE 3). Rainbow trout were the most commonly caught fish in Areas 1 and 2 and MWF were the most commonly caught fish in area 3 (TABLE 3-5).

Overall 15.8% of fish caught were harvested. Anglers harvested a greater proportion of LAT (19.9%) caught than any other species. Anglers harvested 17.9% of RXC, 11.5% of RBT, and only 7.0% of YSC. Only 5.9% of MWF caught were harvested.

TABLE 2. Catch and harvest estimates by species during the 2008 North Fork Shoshone River creel survey.

<u>All Species combined</u>		<u>Brown trout</u>	
Total catch	17,096	Total catch	286
Number Creeled	3,163	Number Creeled	37
Number Released	16,902	Number Released	252
Total Catch/hr	0.82	Total Catch/hr	0.03
Number creeled/hr	0.15	Number creeled/hr	0.00
Number released/hr	0.81	Number released/hr	0.03
<u>Rainbow Trout</u>		<u>Brook trout</u>	
Total catch	7,229	Total catch	105
Number Creeled	830	Number Creeled	-
Number Released	6,399	Number Released	105
Total Catch/hr	0.35	Total Catch/hr	0.01
Number creeled/hr	0.04	Number creeled/hr	-
Number released/hr	0.31	Number released/hr	0.01
<u>Rainbow-cutthroat hybrid</u>		<u>Lake trout</u>	
Total catch	2,794	Total catch	614
Number Creeled	500	Number Creeled	122
Number Released	2,294	Number Released	492
Total Catch/hr	0.13	Total Catch/hr	0.03
Number creeled/hr	0.02	Number creeled/hr	0.01
Number released/hr	0.11	Number released/hr	0.02
<u>Yellowstone cutthroat</u>		<u>Unidentified Trout</u>	
Total catch	2,109	Total catch	494
Number Creeled	147	Number Creeled	26
Number Released	1,962	Number Released	470
Total Catch/hr	0.40	Total Catch/hr	0.11
Number creeled/hr	0.04	Number creeled/hr	0.00
Number released/hr	0.38	Number released/hr	0.10
<u>All Trout</u>		<u>Mountain whitefish</u>	
Total catch	13,631	Total catch	3,466
Number Creeled	1,662	Number Creeled	203
Number Released	11,974	Number Released	3,263
Total Catch/hr	1.06	Total Catch/hr	0.17
Number creeled/hr	0.11	Number creeled/hr	0.01
Number released/hr	0.96	Number released/hr	0.16

TABLE 3. Catch and harvest estimates for sport fish at publicly accessible portions the North Fork Shoshone River from Gibbs Bridge (6KV Bridge) to US Forest Service boundary (Area 1; 1.9 mi) from July 1 to October 31, 2008.

Variable	Estimate	Std Err	CV	Per Mile	Std Err
Hours Fished	4754	697.11	14.7%	2502.1	366.90
Number of Anglers	1446	277.57	19.2%	761.1	146.09
<u>All Species Combined</u>					
Total Catch	4493	909.84	20.3%	2364.9	478.86
Number Harvested	1091	268.97	24.7%	574	141.56
Number Released	3403	697.38	20.5%	1790.9	367.04
Total Catch/hr	0.95	0.10	10.3%		
Number Harvested/hr	0.23	0.04	16.2%		
Number Released/hr	0.72	0.08	11.3%		
<u>Brown trout</u>					
Total Catch	18	9.72	52.8%	9.7	5.12
Number Harvested	6	5.65	100.0%	3	2.97
Number Released	13	7.91	61.9%	6.7	4.16
Total Catch/hr	0.00	0.00	53.1%		
Number Harvested/hr	0.00	0.00	98.2%		
Number Released/hr	0.00	0.00	63.6%		
<u>Lake trout</u>					
Total Catch	523	224.66	42.9%	275.4	118.24
Number Harvested	102	44.80	43.9%	53.7	23.58
Number Released	421	217.16	51.5%	221.8	114.30
Total Catch/hr	0.11	0.04	33.7%		
Number Harvested/hr	0.02	0.01	37.2%		
Number Released/hr	0.09	0.04	43.7%		
<u>Mountain whitefish</u>					
Total Catch	119	59.64	50.1%	62.7	31.39
Number Harvested	19	19.39	100.0%	10.2	10.20
Number Released	100	57.47	57.7%	52.5	30.25
Total Catch/hr	0.03	0.01	51.4%		
Number Harvested/hr	0.00	0.00	94.2%		
Number Released/hr	0.02	0.01	59.5%		
<u>Rainbow trout</u>					
Total Catch	1876	390.92	20.8%	987.5	205.75
Number Harvested	653	183.11	28.0%	343.6	96.37
Number Released	1223	245.79	20.1%	643.8	129.36
Total Catch/hr	0.39	0.05	12.9%		
Number Harvested/hr	0.14	0.03	19.7%		
Number Released/hr	0.26	0.04	14.1%		
<u>Rainbow-cutthroat hybrid trout</u>					
Total Catch	990	296.73	30.0%	520.9	156.17
Number Harvested	232	82.27	35.5%	122	43.30
Number Released	758	252.20	33.3%	398.9	132.74
Total Catch/hr	0.21	0.06	26.4%		
Number Harvested/hr	0.05	0.02	33.2%		
Number Released/hr	0.16	0.05	29.8%		
<u>Unidentified trout</u>					
Total Catch	408	221.93	54.4%	214.6	116.81
Number Harvested	0	0.00	0.0%	0	0.00
Number Released	408	221.93	54.4%	214.6	116.81
Total Catch/hr	0.09	0.04	49.5%		
Number Harvested/hr	0.00	0.00	0.0%		
Number Released/hr	0.09	0.04	49.5%		
<u>Yellowstone cutthroat trout</u>					
Total Catch	559	170.27	30.5%	294	89.61
Number Harvested	79	32.60	41.4%	41.5	17.16
Number Released	480	160.34	33.4%	252.6	84.39
Total Catch/hr	0.12	0.03	21.9%		
Number Harvested/hr	0.02	0.01	39.2%		
Number Released/hr	0.10	0.02	24.5%		

TABLE 4. Catch and harvest estimates for sport fish in the North Fork Shoshone River from the US Forest Service boundary to Newton Creek (Area 2; 14.4 mi) from July 1 to October 31, 2008.

Variable	Estimate	Std Err	CV	Per Mile	Std Err
Hours Fished	9735	801.72	8.2%	676	55.68
Number of Anglers	2791	233.84	8.4%	193.8	16.24
<u>All Species Combined</u>					
Total Catch	8079	1049.22	13.0%	561.1	72.86
Number Harvested	1531	313.71	20.5%	106.3	21.79
Number Released	6548	945.08	14.4%	454.8	65.63
Total Catch/hr	0.83	0.07	8.7%		
Number Harvested/hr	0.16	0.03	16.9%		
Number Released/hr	0.67	0.07	11.1%		
<u>Brook trout</u>					
Total Catch	34	21.18	61.8%	2.4	1.47
Number Harvested	0	0.00	0.0%	0	0.00
Number Released	34	21.18	61.8%	2.4	1.47
Total Catch/hr	0.00	0.00	60.4%		
Number Harvested/hr	0.00	0.00	0.0%		
Number Released/hr	0.00	0.00	60.4%		
<u>Brown trout</u>					
Total Catch	118	57.88	49.0%	8.2	4.02
Number Harvested	15	10.67	73.4%	1	0.74
Number Released	104	54.89	53.0%	7.2	3.81
Total Catch/hr	0.01	0.01	46.4%		
Number Harvested/hr	0.00	0.00	73.5%		
Number Released/hr	0.01	0.01	50.2%		
<u>Lake trout</u>					
Total Catch	81	28.04	34.4%	5.7	1.95
Number Harvested	20	11.88	58.2%	1.4	0.83
Number Released	61	21.60	35.4%	4.2	1.50
Total Catch/hr	0.01	0.00	33.7%		
Number Harvested/hr	0.00	0.00	56.0%		
Number Released/hr	0.01	0.00	35.7%		
<u>Mountain whitefish</u>					
Total Catch	1224	266.33	21.8%	85	18.50
Number Harvested	153	64.48	42.3%	10.6	4.48
Number Released	1072	247.69	23.1%	74.4	17.20
Total Catch/hr	0.13	0.02	18.5%		
Number Harvested/hr	0.02	0.01	39.1%		
Number Released/hr	0.11	0.02	20.3%		
<u>Rainbow trout</u>					
Total Catch	2884	787.57	27.3%	218.5	59.66
Number Harvested	284	113.10	39.8%	21.5	8.57
Number Released	2600	809.34	31.1%	197	61.31
Total Catch/hr	0.62	0.18	28.2%		
Number Harvested/hr	0.06	0.02	38.7%		
Number Released/hr	0.56	0.18	32.1%		
<u>Rainbow-cutthroat hybrid trout</u>					
Total Catch	859	288.23	33.6%	65.1	21.84
Number Harvested	134	66.69	49.8%	10.1	5.05
Number Released	725	297.90	41.1%	54.9	22.57
Total Catch/hr	0.19	0.06	34.2%		
Number Harvested/hr	0.03	0.01	47.2%		
Number Released/hr	0.16	0.07	42.2%		
<u>Unidentified trout</u>					
Total Catch	43	38.73	89.2%	3.3	2.93
Number Harvested	13	12.80	100.0%	1	0.97
Number Released	31	26.09	85.2%	2.3	1.98
Total Catch/hr	0.01	0.01	90.0%		
Number Harvested/hr	0.00	0.00	100.7%		
Number Released/hr	0.01	0.01	86.1%		
<u>Yellowstone cutthroat trout</u>					
Total Catch	754	158.06	21.0%	57.1	11.97
Number Harvested	34	15.63	46.1%	2.6	1.18
Number Released	720	149.96	20.8%	54.6	11.36
Total Catch/hr	0.16	0.04	23.3%		
Number Harvested/hr	0.01	0.00	47.7%		
Number Released/hr	0.16	0.04	23.1%		

TABLE 5. Catch and harvest estimates for sport fish in the North Fork Shoshone River from Newton Creek to Pahaska (Area 3; 13.2 mi) from April 15 to October 31, 2008.

Variable	Estimate	Std Err	CV	Per Mile	Std Err
Hours Fished	6454	735.21	11.4%	488.9	55.70
Number of Anglers	2197	293.61	13.4%	166.5	22.24
<u>All Species Combined</u>					
Total Catch	7492	1119.51	14.9%	567.5	117.20
Number Harvested	541	175.00	32.3%	41	15.33
Number Released	6951	1154.93	16.6%	526.5	120.30
Total Catch/hr	1.16	0.47	40.3%		
Number Harvested/hr	0.08	0.04	47.0%		
Number Released/hr	1.08	0.47	43.7%		
<u>Brook trout</u>					
Total Catch	71	34.90	49.1%	5.3	2.64
Number Harvested	0	0.00	0.0%	0	0.00
Number Released	71	34.90	49.1%	5.3	2.64
Total Catch/hr	0.01	0.01	69.1%		
Number Harvested/hr	0.00	0.00	0.0%		
Number Released/hr	0.01	0.01	69.1%		
<u>Brown trout</u>					
Total Catch	150	87.67	58.4%	11.4	8.81
Number Harvested	16	9.71	60.7%	1.2	0.74
Number Released	135	85.70	63.5%	10.2	8.65
Total Catch/hr	0.02	0.03	116.4%		
Number Harvested/hr	0.00	0.00	84.7%		
Number Released/hr	0.02	0.03	127.8%		
<u>Lake trout</u>					
Total Catch	9	6.62	73.6%	0.7	0.50
Number Harvested	0	0.00	0.0%	0	0.00
Number Released	9	6.62	73.6%	0.7	0.50
Total Catch/hr	0.00	0.00	100.4%		
Number Harvested/hr	0.00	0.00	0.0%		
Number Released/hr	0.00	0.00	100.4%		
<u>Mountain whitefish</u>					
Total Catch	2122	469.70	22.1%	160.7	47.86
Number Harvested	31	25.80	83.2%	2.3	1.96
Number Released	2092	470.03	22.5%	158.4	47.92
Total Catch/hr	0.33	0.28	84.9%		
Number Harvested/hr	0.00	0.01	116.6%		
Number Released/hr	0.32	0.28	86.1%		
<u>Rainbow trout</u>					
Total Catch	471	181.38	38.5%	35.7	13.74
Number Harvested	30	30.00	100.0%	2.3	2.27
Number Released	441	173.78	39.4%	33.4	13.17
Total Catch/hr	0.07	0.11	157.4%		
Number Harvested/hr	0.00	0.02	344.2%		
Number Released/hr	0.07	0.11	162.6%		
<u>Rainbow-cutthroat hybrid trout</u>					
Total Catch	86	62.46	72.6%	6.5	4.73
Number Harvested	0	0.00	0.0%	0	0.00
Number Released	86	62.46	72.6%	6.5	4.73
Total Catch/hr	0.01	0.03	260.4%		
Number Harvested/hr	0.00	0.00	0.0%		
Number Released/hr	0.01	0.03	260.4%		
<u>Yellowstone cutthroat trout</u>					
Total Catch	42	42.29	100.7%	3.2	3.20
Number Harvested	0	0.00	0.0%	0	0.00
Number Released	42	42.29	100.7%	3.2	3.20
Total Catch/hr	0.01	0.02	365.7%		
Number Harvested/hr	0.00	0.00	0.0%		
Number Released/hr	0.01	0.02	365.7%		

Of the 1,163 interviews conducted 553 interviews were from anglers that had finished fishing for the day. Based on these completed trips, less than one percent did not catch any fish (FIGURE 5). Eighty percent of anglers caught three or more fish. A large majority of anglers (76.7%) did not harvest any fish, 15.2% of anglers harvested one fish, 6.3% harvested two fish, and 1.8% harvested three fish (the creel limit).

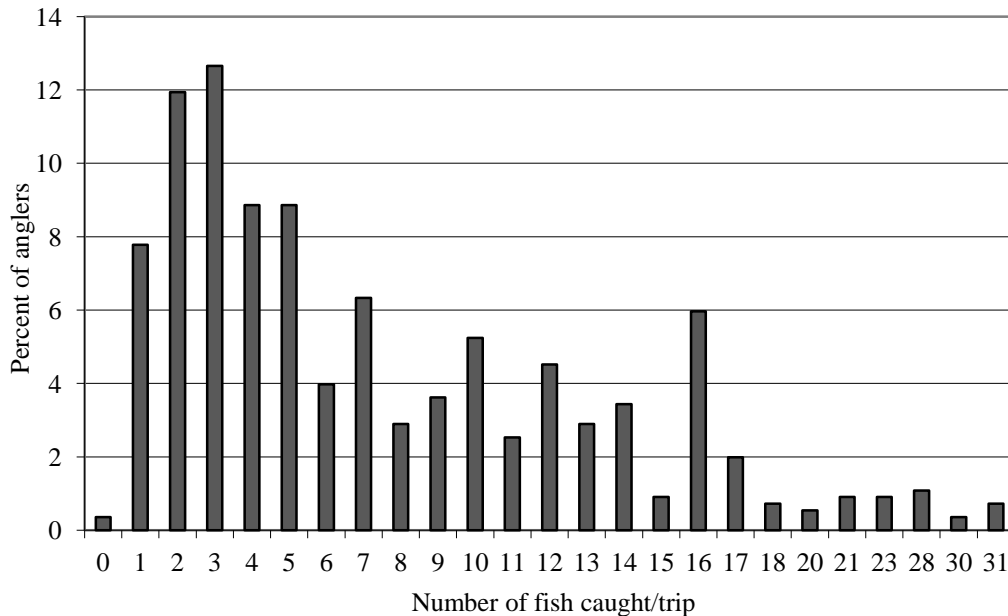


FIGURE 5. Number of fish caught per angler from completed trip interviews during the 2008 North Fork Shoshone creel survey.

Anglers had an exceptional average catch rate of 0.82 fish per hour. Of the 1,163 interviews collected, 731 anglers fished for at least one hour. These 731 interviews were used to calculate the $PAS_{0.5} = 0.49$ (i.e., 49% of anglers caught at least one fish in two angling hours).

Spot creel surveys

An average of 353 angler interviews per year were conducted on the NFSR by the Cody Fisheries Management crew and game wardens, accounting for an average of 740 angling hours per year from 1976 to 2008 (FIGURE 6). Average catch rates have remained above 0.5 fish per hour since 2001. A dramatic shift in the proportion of anglers harvesting fish was experienced in 2001. Prior to 2001, a majority of anglers harvested their catch. Catch rates increased from 0.2 fish/hour in 2000 to over one fish/hr in 2001, but the harvest rate of 0.2 fish/hour has remained relatively constant since that time. A $PAS_{0.5}$ could not be calculated for past spot creels, since anglers were not interviewed individually, but rather as a group.

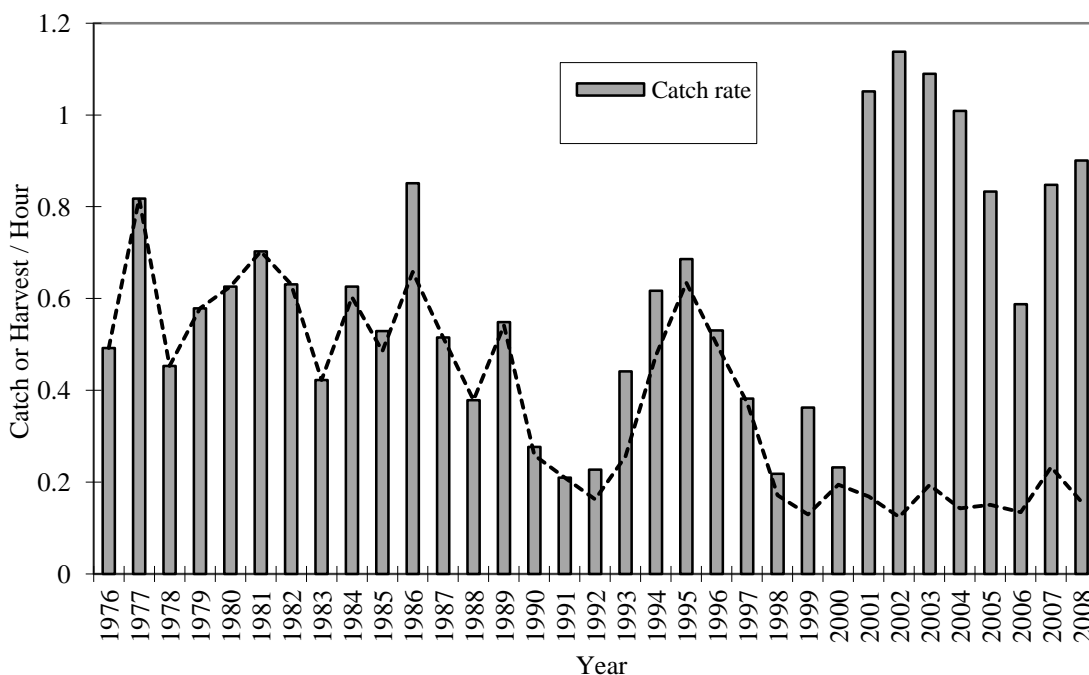


FIGURE 6. Catch and harvest statistics for programmed creel surveys conducted in 2008, 1991, 1979, and 1978 , and spot creel surveys conducted since 1976.

Fish population estimates

Total trout population estimates were just over 600 per mile with biomass estimates just over 700 pounds per mile in each reach. In both sections, the combination of RBT and RXC comprised approximately 80 percent of the trout population, and YCT accounted for approximately 20 percent of the trout population.

TABLE 6. Species composition, mean lengths with ranges, mean weight with ranges, population estimates with coefficient of variation (cv), biomass estimates with cv, and mean relative weights for trout longer than or equal to 6 inches captured during four consecutive days of sampling with two rafts with fixed electrodes in the North Fork Shoshone River from Rivers Rest to the 6FU access area, August 2008.

Species	No.	Mean Length	Length Range	Mean Weight	Weight Range	No./Mile (cv %)	Lb/Mile (cv %)	Mean Wr
Brown trout	7	15.9	8.1-19.5	1.37	0.18-2.34	3 (40.4)	4.0	30.6
Lake trout	5	18.4	17.1-19.5	1.51	1.06-1.84	1	2.0	21.4
Rainbow trout	164	13.7	6.0-19.8	1.06	0.04-2.60	169 (20.0)	183.3	33.4
Rainbow-cutthroat hybrid	290	14.7	6.1-21.7	1.11	0.01-3.02	301 (15.3)	336.8	7.8
Yellowstone cutthroat	189	15.8	6.3-20.4	1.31	0.06-2.36	133 (13.7)	177.6	8.1
All trout	655	14.8	6.0-21.7	1.16	0.04-3.02	608 (9.9)	704.0	9.7

TABLE 7. Species composition, mean lengths with ranges, mean weight with ranges, population estimates with coefficient of variation (cv), biomass estimates with cv, and mean relative weights for trout longer than or equal to 6 inches captured during four consecutive days of sampling with two rafts with fixed electrodes in the North Fork Shoshone River from Mummy Cave to Elks Fork, July 2006.

Species	No.	Mean Length	Length Range	Mean Weight	Weight Range	No./Mile (cv%)	Lbs/Mile (cv%)	Mean Wr
Brook trout	1	7.0		0.20				104
Brown trout	18	13.4	7.3-20.4	1.16	0.1-3.9	4 (25.8)	6.0 (28.5)	94
Rainbow trout	202	10.1	6.2-18.3	0.48	0.1-2.4	220 (29.2)	122.2 (14.1)	104
Rainbow-cutthroat hybrid	279	14.8	6.0-20.9	1.46	0.1-3.0	256 (22.2)	365.7 (10.3)	88
Yellowstone cutthroat	194	16.5	6.4-20.8	1.75	0.1-2.9	122 (20.6)	210.4 (11.3)	87
All trout	698	13.9	6.0-20.9	1.25	0.1-3.9	603 (14.9)	704.3 (6.8)	95

Discussion

Angler demographics have shifted substantially since the 1991 NFSR creel survey. Major shifts have occurred in angler residence, tackle type, and harvest trends. Nonresident anglers now outnumber resident anglers. It is unknown what effect environmental factors had in the proportion of resident versus nonresident anglers fishing the NFSR in 2008. Kent (1995) reported that poor water conditions caused by sediment produced by the 1988 fires probably led to reduced fishing pressure in 1991. August had the highest angling pressure in 2008, whereas nearly half of the angling pressure was experienced in July during the 1991 creel survey. Poor water conditions through mid July likely suppressed angler turnout during this period when a majority of nonresidents are present in Cody and surrounding areas.

Fly anglers are now outnumber anglers using bait and lures. It is possible this trend would have been increased with better water conditions. Turbidity through much of the angling season may have turned anglers to bait or lures that tend to be more effective in those conditions. Nonresidents were primarily fly anglers and poor water conditions likely discouraged many nonresident anglers in 2008.

Significantly fewer anglers fished the NFSR than the in 1991; however, angling pressure was not significantly different due to the longer average angling day of individual anglers. Overall, angling pressure was lower than expected, which is likely associated with high and turbid water conditions experienced in 2008. The Gunbarrel Fire that burned much of the NFSR drainage north of the river and related firefighting activities may have also impacted angling pressure.

Environmental factors ranging from higher than average stream flows to wildfire likely affected angler turnout in 2008. Snowpack was well above average in 2008 for the NFSR drainage. The NFSR typically has mean daily flows that peak near 3,500 cfs near the middle of June and recede to below 1,500 cfs by the middle of July (

FIGURE 7). Mean daily flows peaked over 8,000 cfs near the first of July 2008 and remained above 1,500 cfs through July. Periodic rainstorms were reported by creel clerks during the 2008 angling season and water clarity was reported as being “muddy” through June with

water commonly being reported as “off color” through September (FIGURE 8). Significantly fewer anglers were counted on days when the water was reported as “muddy” than when it was reported as “clear” or “off color” (Kruskal-Wallis One Way Analysis of Variance on Ranks, $P = <0.001$).

The Gunbarrel Fire started July 26, 2008 and burned 68,149 ac of the northern portion of the North Fork Shoshone River drainage by the time it was declared extinguished in December 2008. At times, this fire was burning reached the shoulder of Highway 14-16-20. While the fire never caused closure of Highway 14-16-20, a pilot-car system was used to lead traffic along the highway during firefighting activities. Creel clerks noted “smokey” conditions on a number of creel count days. Poor air quality was common, due to the Gunbarrel and other fires within Yellowstone National Park, which may have affected angler turnout.

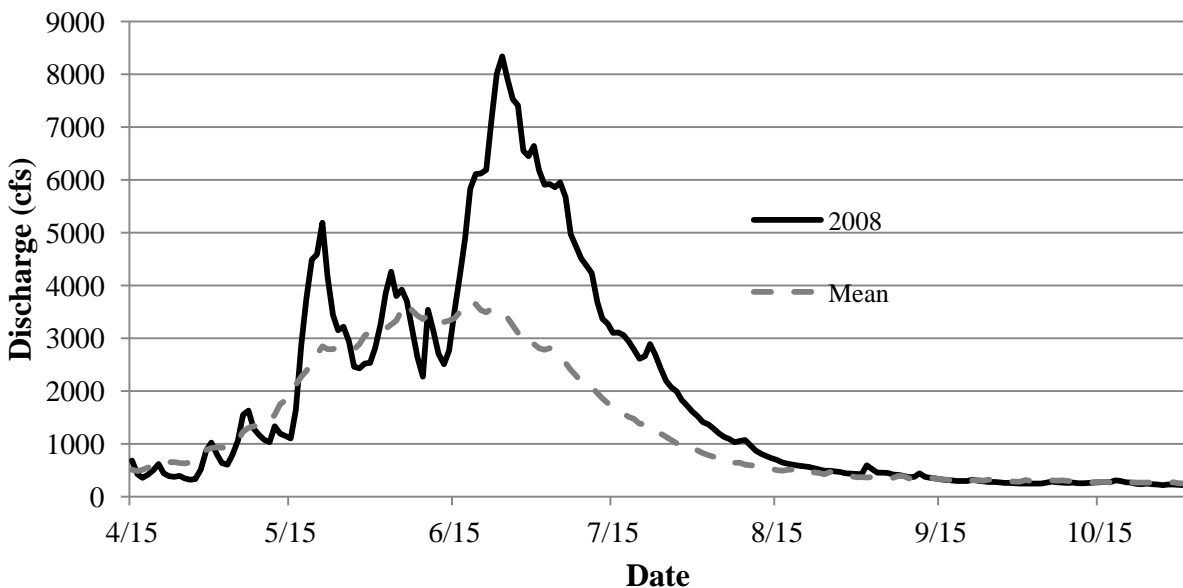


FIGURE 7. Discharge data for the North Fork Shoshone River at Wapiti, WY including the daily mean discharge for the 2008 North Fork Shoshone River creel survey (April 15-October 31) and the mean daily flows for the same time period over the 19 years of record at that site.

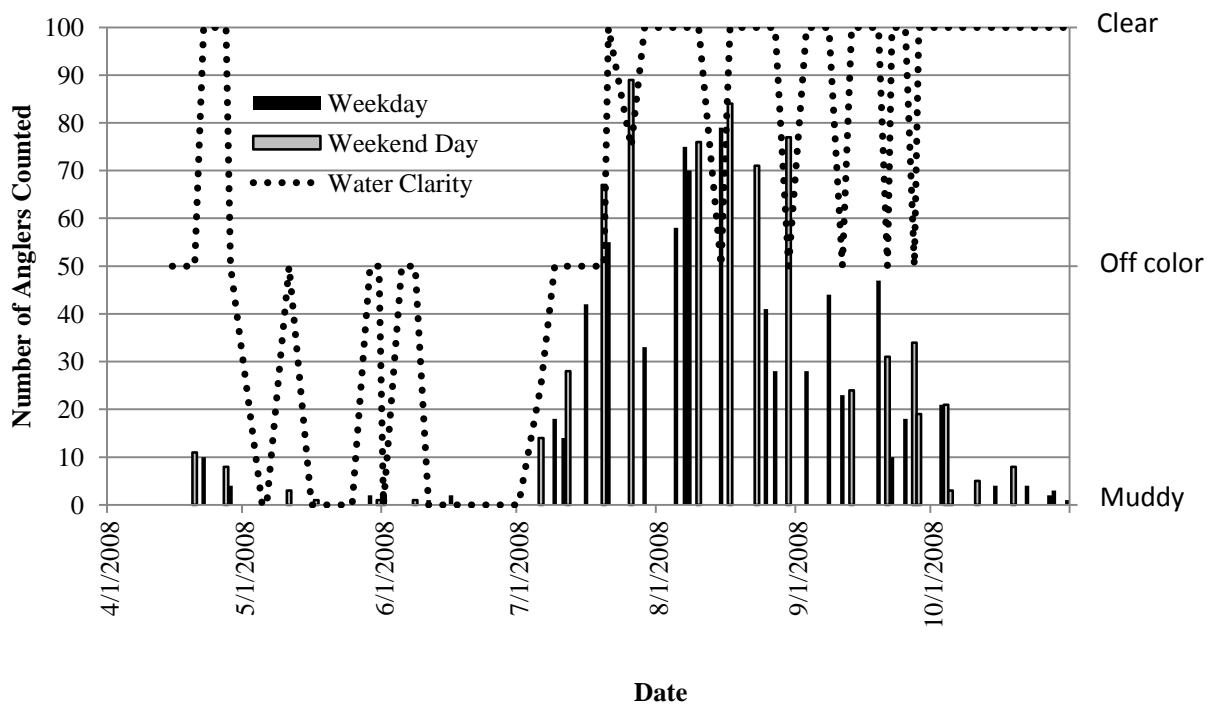


FIGURE 8. Angler counts and creel clerk reported water clarity during the 2008 North Fork Shoshone creel survey.

Angler catch rate (0.82 fish/hr) is exceptional for this water, especially considering the turbid water conditions anglers experienced in 2008. The $PAS_{0.5}$ was only 0.49 and may be due to variable environmental conditions or the large number of inexperienced tourists that fish the NFSR.

Anglers reported RBT to be the most frequently caught fish in 2008. Differentiating RBT from RXC is very difficult. A campaign to educate anglers on the differences between YCT and RBT or RXC was initiated and was done in conjunction with this creel survey, since a cutthroat specific regulation was put into effect on the NFSR in 2008. We believe anglers have been more effective at differentiating YCT from RBT or RXC by utilizing characteristics such as white on the tips of anal and pelvic fins, spotting pattern and jaw slashes. Anglers have more difficulty with the admittedly difficult task of distinguish between RBT and RXC.

Anglers harvested 15.8% of the fish they caught, which is substantially higher than harvest rates on other blue color-class waters where Programmed Creel surveys were conducted over the last decade, the North Platte River-Miracle Mile (6% harvest rate, Cook 2012), and the North Platte River at Grey Reef (1.7% harvest rate; Hahn 2013).

The average number of fish per mile in the 2006 and 2008 population estimates was 605.5 trout per mile. Extrapolating this number to the 40.3 mi of NFSR from Gibbs Bridge to Pahaska estimates 24,400 trout in the NFSR. Because trout in the NFSR are mobile, moving from Buffalo Bill Reservoir to the NFSR tributaries and then returning within the same year, this is likely a gross under estimation of the total trout population in the NFSR system as fish are entering the river from the tributaries and emigrating to the reservoir. The programmed creel survey indicates that 13,631 trout were caught and 1,662 were harvested. Because the overall population size is a conservative estimate, and an individual fish can be caught multiple times (if it is not harvested or die from angling induced trauma), it can be assumed that anglers caught no

more than 56% of the trout in the NFSR in 2008 and harvested no more than 7% of the trout population.

Much higher levels of exploitation are needed to negatively affect wild trout populations. Welker (1993) suggested an exploitation rate of 35% will deplete trophy sized trout populations in the Middle Fork Powder River of Wyoming. Cox and Walters (2002) showed maximum sustained yield (optimal exploitation) at 33% and 56% in low productivity and high productivity lakes, respectively in British Columbia.

Recommendations

Continue to manage the NFSR as a blue ribbon fishery with a biomass >600 lb/mi. with periodic monitoring standard sampling stations.

Continue to collect spot creel data. These data have been useful in tracking angler catch and harvest rates. Begin collecting spot creel data for individual anglers to allow for the calculation of proportional angler success. Establish a catch rate objective of $PAS_{0.5}$ 0.50 for the NFSR.

A better understanding of trout demographic dynamics is necessary to determine the possible impacts of angling regulation changes. Natural mortality rates as they relate to angler induced mortality are unknown. More information on trout demographics (i.e. natural mortality rate, age composition of the trout population, etc) is needed to determine if a change in angling regulations would have a substantive change in population size or size distribution.

Additional information is needed to determine trout movement patterns in the NFSR. A seasonal angling closure is a very restrictive angling regulation. Investigate opportunities to modify angling regulations to improve angling opportunities while still conserving the wild trout fishery.

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