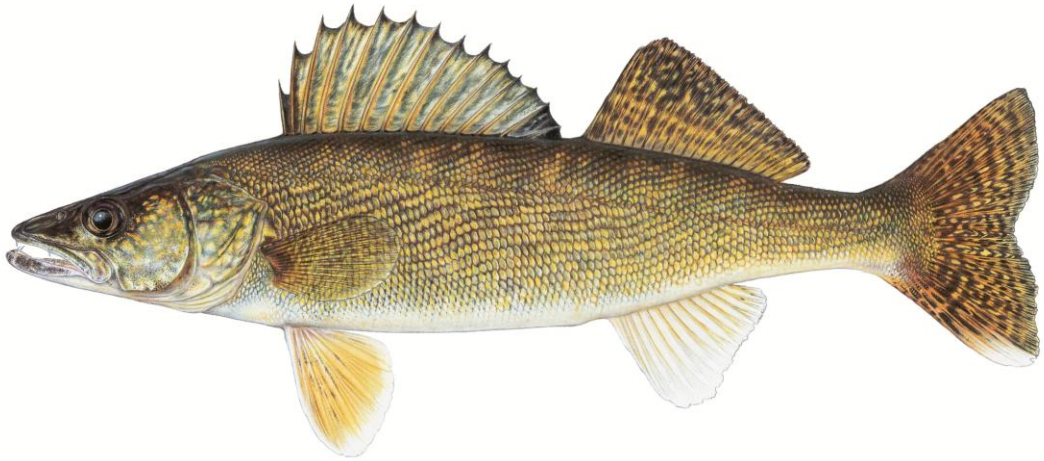
An Evaluation of Walleye in the Missouri River between Holter Dam and Great Falls, Montana

PPL-Montana MOTAC projects 771-09, 771-10, 759-11, 771-11

and

Fisheries Bureau Federal Aid Job Progress Report
Federal Aid Project Number F-113-R9, R10, R11, R12
Montana Statewide Fisheries Management



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Introduction

For nearly 40 years a walleye fishery has existed in the short reach of the Missouri River below Holter Dam. Increasing nationwide interest in walleye angling over the past 30 years has led to the development of many new walleye fisheries in Montana. The Missouri River between Holter Dam and Great Falls offers opportunity for walleye angling at three principle sites; Holter Dam, Cascade and Great Falls. Local newspaper articles have chronicled angler catches of trophy class walleye, approaching 10 pounds, in this reach of river. Although walleye catches are localized to a few areas, are seasonal, and catch rates are typically low, there has been increasing public use of the walleye fishery in this reach of river. These developments prompted regional fisheries personnel to initiate monitoring and research programs to better understand basic aspects of this developing walleye fishery.

From 2008-11, Montana Fish, Wildlife & Parks (MFWP) conducted studies of walleye behavior, harvest, diet, and distribution in the Missouri River between Holter Dam and Great Falls. These studies were funded PPL-Montana MOTAC projects 771-09, 771-10, 759-11, 771-11 as part of FERC license 2188, and by the Federal Aid-Montana Statewide Fisheries Management Program.

Study Area

The study area consists of an 88-mile reach of the Missouri River spanning from Holter Dam to Black Eagle Dam (Figure 1). The major tributaries include Little Prickly Pear Creek, Dearborn River, Sheep Creek, Smith River and Sun River. The minor tributaries include Hardy Creek, Bird Creek, Little Muddy Creek and Sand Coulee Creek.

River flow in this section is regulated by three upstream hydroelectric dams (Canyon Ferry, Hauser and Holter dam). Annual mean flow measured below Holter Dam from 1948 to 2011 ranged from 3,120 to 8,439 cubic feet per second (cfs) (USGS unpublished data for station 06066500) (Figure 2). The annual peak flow from 1946 through 2011 ranged from 3,370 to 34,800 cfs (Figure 3). From 1999 through 2007 a drought occurred in central Montana resulting in peak flows in the Missouri River to be far below the long term average.

In 1987 MFWP was directed by the Fish & Game Commission to develop river management plans on the top ten rivers in Montana, including this section of the Missouri River. MFWP developed a 5 year (1990-94) plan that stated "*…the management goal for the Missouri River from Holter Dam to Cascade is to maintain and enhance for public use, a blue ribbon wild trout fishery dominated by 14 to 17 inch rainbow trout with a greater opportunity to catch large trophy brown trout. From Cascade to Great Falls, the management goal is to enhance and diversify fishing opportunities…"* (MFWP 1990). The plan adopted 20 management actions to help achieve the goals. These actions included issues such as harvest regulations, habitat enhancement and social issues. One action considered by the plan was to "*…evaluate the potential for enhancing warm/cool water species including smallmouth bass and walleye in the reach between Cascade and Great Falls…"* (MFWP 1990).

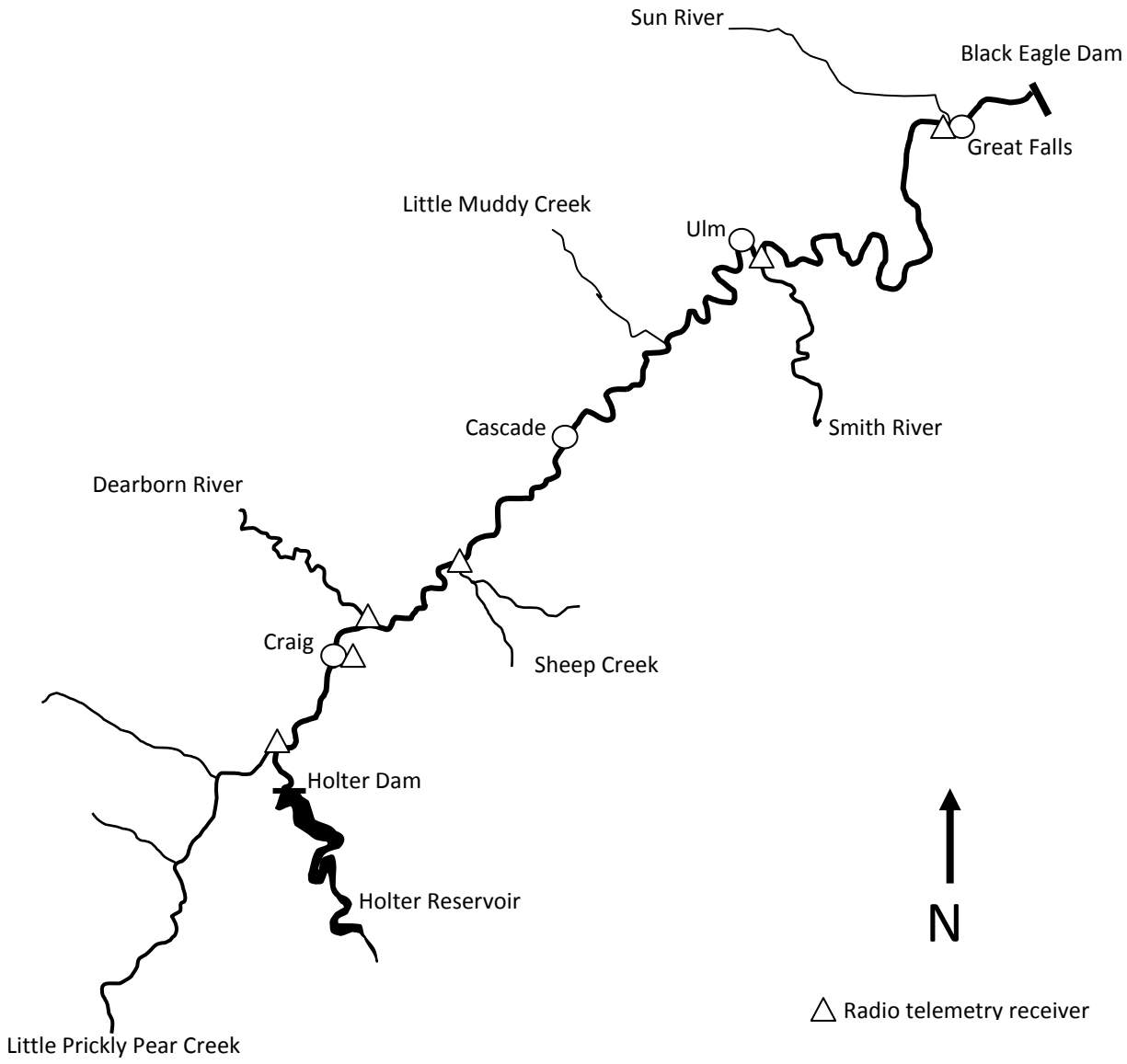

Figure 1. Map of the Missouri River study area from Holter Dam to Black Eagle Dam with associated landmarks and radio telemetry receiver stations.

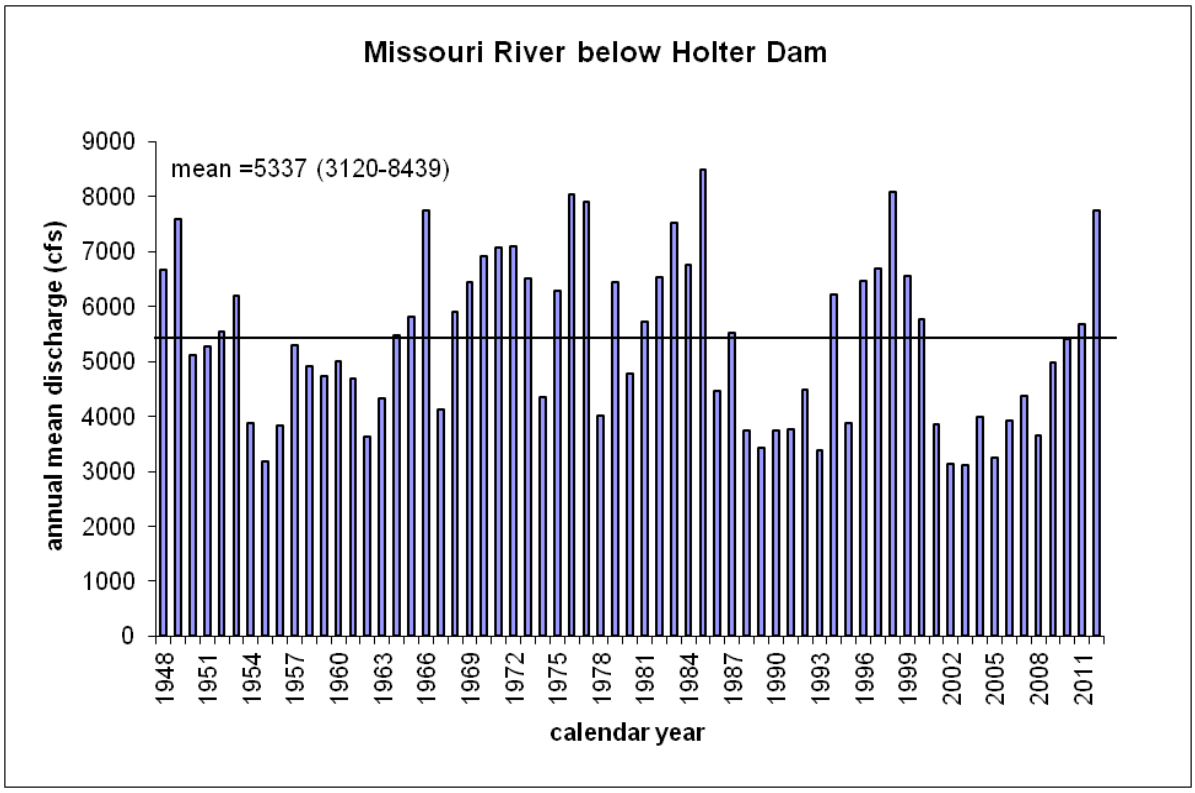

Figure 2. Annual mean flow of the Missouri River below Holter Dam, 1948-2011.

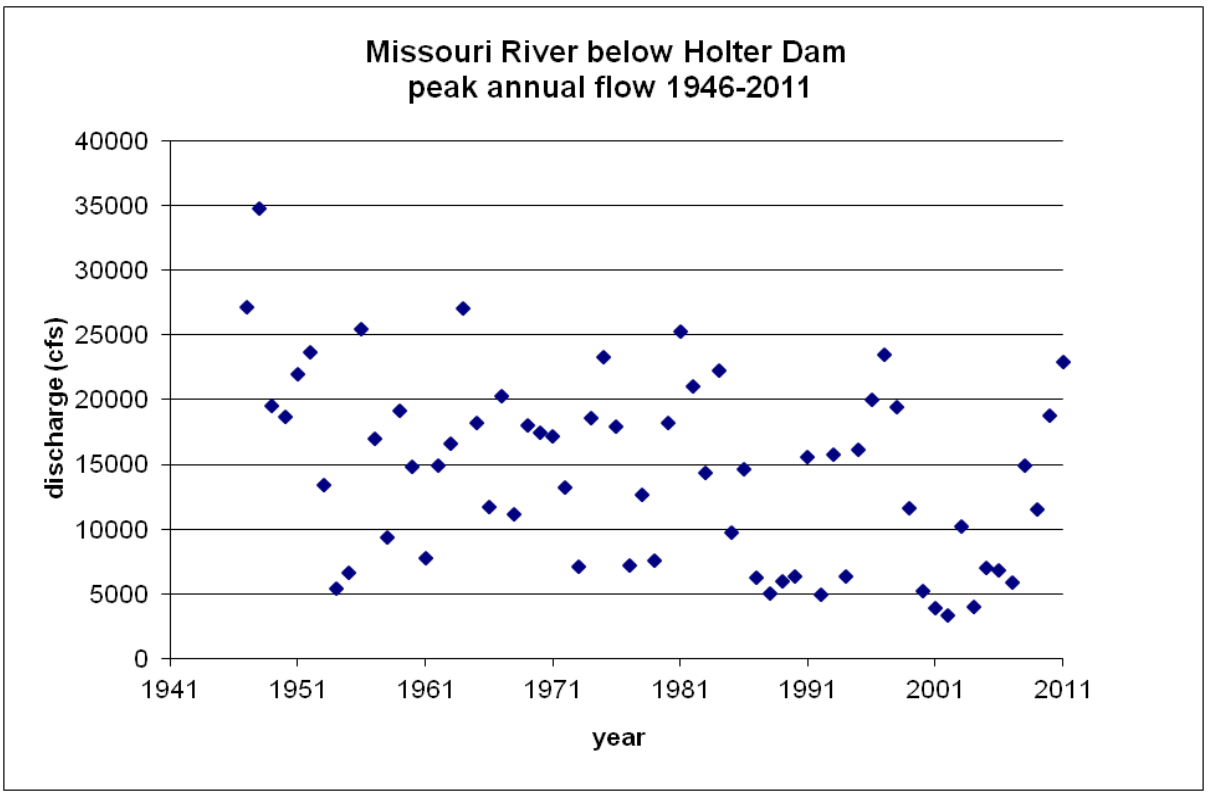

Figure 3. Annual peak flow of the Missouri River below Holter Dam, 1946-2011.

The upper 30 miles of river from Holter Dam to Cascade Bridge (section 9) has been managed primarily as a trout fishery (MFWP 1990). Mountain whitefish and walleye make up the balance of game fish sought by anglers. Angler use statistics from 1991-2009 show the Missouri River – section 9 had a mean 91,100 (range 62,000-123,000) angler days per year (Table 1). During the same time period, this fishery ranked in the top five fisheries in the state and was the number one fishery in Montana in 2001. Angler use averages 72% resident and 28% non-resident, but trends show a slight increase in nonresident use.

Table 1. Angler use statistics for Missouri River section 9, 1991-2009.

year	Angler days	State rank	Reg rank	%Res	%Non Res	No. 1 fishery	Angler days
2009	106,746	4	2	63	37	Canyon Ferry Res.	133,220
2007	78,468	4	2	68	32	Madison R. (sec 2)	106,330
2005	93,229	2	1	64	36	Madison R. (sec 2)	116,345
2003	106,447	2	1	61	39	Madison R. (sec 2)	115,342
2001	123,427	1	1	69	31	---	---
1999	111,203	3	1	79	21	Canyon Ferry Res.	119,886
1997	88,576	4	1	75	25	Fort Peck Lake	108,562
1995	75,201	2	1	75	25	Canyon Ferry Res.	94,731
1993	62,179	5	3	81	19	Canyon Ferry Res.	93,782
1991	65,526	5	3	85	15	Madison R. (sec 2)	68,623

Economic statistics for angler use are based on a 1985 survey conducted by MFWP in which resident and non-resident anglers were surveyed to determine what goods and services they purchased during a typical fishing trip. The dollar value of an angler day was based on expenditures for non-durable goods typically purchased per trip such as food, gasoline, bait, lures, license, outfitter-guide fees and lodging. Durable goods such as boats, waders, fishing rods and vehicles were not included in the calculation because their value is normally amortized over the life of their use. As such, the economic value of an angler day in Montana is conservative because only expenditures for non-durable goods were included. Angler day values have been adjusted bi-annually based on estimates of the Consumer Price Index provided by the United States Department of Labor- Bureau of Labor Statistics. From 1995 through 2009, the mean annual revenue generated by this 30 mile reach of river was $8.6 million (range 4.9-12.1) (Table 2).

Table 2. Economic statistics for the Missouri River section 9, 1995-2009.

year	Resident value $	Non-res Value $	Total Angler days	Resident Angler days	Non-resident Angler days	Total
2009	44.55	232.53	106,746	67,266	39,480	$12,176,984.70
2007	43.04	224.65	78,468	53,604	24,864	$7,892,813.76
2005	40.43	211.03	93,229	59,762	33,467	$9,478,718.67
2003	38.13	199.04	106,447	64,854	41,593	$10,751,553.74
2001	36.8	192.06	123,472	84,860	38,612	$10,538,668.72
1999	34.57	180.42	111,203	87,768	23,435	$7,262,282.46
1997	33.23	173.44	88,576	66,179	22,397	$6,083,663.85
1995	32.34	168.78	75,201	56,613	18,588	$4,968,147.06
Average			97,918	67,613	30,305	$8,644,104.12

The Missouri River section 8 is a 58-mile reach of river that spans from the Cascade Bridge to Black Eagle Dam. This section is managed as a mixed species fishery (MFWP 1990). Angling occurs predominantly for trout, walleye, burbot and bowfishing for carp. Angler use statistics from 1991 through 2009 show this section receives a mean 19,692 (range 12,000-28,000) angler days per year and mean rank is number 34 (range 27-45) in the state (Table 3). When angler use and economic figures for both sections 8 and 9 are combined the mean angler days per year for the period of record was 110,782 (range 77,000-148,000) angler days per year and mean annual revenue generated from these fisheries was $9.9 million (range $5.5-14.2 million) (Table 3).

Table 3. Angler use statistics for Missouri River section 8, combined angler days with section 9, and economic statistics for section 8 and section 9, 1991-2009.

year	Angler days	State rank	Reg rank	%Res	%Non Res	Sec 9 Angler	Total AD Sec 8 & 9	Total revenue Sec 8 & 9
2009	28,883	29	6	86	14	106,746	135,629	$14,223,842.04
2007	15,909	35	5	88	12	78,468	94,377	$8,924,245.14
2005	18,973	37	6	81	19	93,229	112,202	$10,860,787.88
2003	20,368	31	5	80	20	106,447	126,815	$12,183,668.56
2001	24,681	28	5	89	11	123,427	148,108	$11,868,446.45
1999	26,447	27	4	90	10	111,203	137,650	$8,562,284.75
1997	17,919	34	6	85	15	88,576	106,495	$7,055,975.67
1995	12,964	45	6	88	12	75,201	88,165	$5,599,659.80
1993	15,356	41	7	91	9	62,179	77,535	---
1991	15,419	36	7	93	7	65,526	80,945	---
avg	19,692	34	6	87	13	91,100	110,792	$9,909,863.78

Creel survey

Creel surveys were conducted in this reach of river in 1993, 1994, 1995, 1998, 2001 and 2002 (Horton and Liknes 2003, Horton and Clark 2004). The 1993-2001 creels showed low catch rates of walleye ranging from 0.014 to 0.028 fish per hour. Catch rates were based on observations of 1 to 3 walleye harvested per angler. During this time frame, the Holter section was the only site where walleye were creeled and all walleye catches occurred in May. The 2002 creel showed the yearlong walleye catch rate was 0.01 (range 0.019-0.361) fish per hour. Walleye were caught only in the Holter section and an estimated 260 walleye were harvested in 2002 in the Holter section (Horton and Clark 2004).

In 2002, 74% of all anglers interviewed used flies, 13% used bait (other than fish eggs), 7.3% used lures, 3.5% used any combination, and 2.1% used fish eggs (Horton and Clark 2004).

Angling

Although walleye angling is considered localized to a few areas, seasonal in the spring and fall, and catch rate is typically low, there are three principle areas in this section of river where anglers reliably catch walleye.

The ***Holter*** area is a 1.8 mile reach of the Missouri River immediately below Holter Dam. Anglers fish for walleye using crank baits, jigs and streamer flies. Angling occurs at five sites in this short reach; 1) from the shore on the right bank at the base of the dam spillway, 2) anchored in a boat approximately 30 yards off shore between the warning cable and the BLM boat ramp, 3) from the shore on the left bank at the BLM camp ground where the river makes a 90^{o} bend, 4) from the shore on the left bank approximately 150 yards downstream of the 90^{o} bend in the river, and 5) from a boat or by wade fishing from the downstream point of the small island located 1.8 miles downstream of the dam. Anglers have the best success fishing during twilight hours in the spring and fall. This location provides a unique opportunity for walleye angling from the shore.

The ***Cascade*** area is a 1.9 mile reach of river from the mouth of Bird Creek downstream to the mouth of Little Muddy Creek. Anglers fish for walleye at three sites within this reach. Site 1 is the high cut bank on river right immediately below the mouth of Bird Creek. Anglers drift in boats along this bank while casting jigs and troll upstream with crank baits. Site 2 is the deep hole 0.3 mile downstream of Bird Creek near the site of car bodies on the left bank and a house overlooking the river on the right bank. Anglers anchor in this hole and jig from the bottom. Site 3 is located at the mouth of Little Muddy Creek. Anglers drift in boats through this reach of river while casting crank baits and jigs, then troll upstream with crank baits. A limited amount of success has occurred by casting crankbaits from the shore. This area typically caters to anglers who have the means of a jet boat to gain access through shallow water to reach their destinations.

The ***Great Falls*** area is a 2.2 mile reach of the Missouri River that spans from the upper most point of Taylor Island downstream to the mouth of the Sun River, and a 0.6 mile reach of the Sun River from the 6^{th} Street Bridge downstream to the mouth. Angling occurs at five sites in this reach. Site 1 is located in the west side channel of Taylor Island. Anglers troll upstream with boats using crankbaits or fish from docks on the left bank. Site 2 is located in the furthest east side channel at the Park Island complex where Lower River Road parallels the river. Anglers

drift in boats while casting crank baits and jigging through this side channel, then troll crankbaits upstream. Site 3 is located at the downstream point of Park Island. Anglers anchor boats in this deep hole and jig from the bottom. Site 4 is located in the west side channel of Park Island. Anglers drift in boats while jigging and troll crankbaits along the left bank between the uppermost point of the car bodies downstream to the mouth of the Sun River. Site 5 is located near the mouth of the Sun River. Anglers fish from the shore on the left bank between the Warden Bridge and the mouth of the Sun River then upstream in the Sun River to the uppermost golf cart shed. This area caters mostly to anglers who use propeller driven boats to travel the short distance upstream from the Broadwater Bay boat ramp. A much smaller proportion of jet boat anglers and shore anglers use this site.

Fish abundance

Since 1981 MFWP has conducted annual mark-recapture population estimates for trout in two sections of the Missouri River downstream of Holter Dam. The Craig section spans 5.6 miles from Wolf Creek Bridge downstream to the Craig Bridge (USGS river miles 2199.5 to 2193.9). The Cascade section spans 4.1 miles from the mouth of Hardy Creek downstream to the irrigation pumps on the left bank (USGS river miles 2177.5-2173.6). In May each year two jet boats were used in the Craig section for night-time electrofishing (SDC, ≈300 V, 4A) along each bank to capture and mark brown trout for two nights. Marked fish were allowed to redistribute for one week then electrofishing was resumed for two nights of recapture. In the Cascade section, one boat was used in May to capture brown trout for one night on the left bank, then one night on the right bank. Marked fish were allowed to redistribute for one week then electrofishing was resumed for two nights of recapture; one night on each bank, respectively. In October a similar protocol was used to estimate rainbow trout. The only differences were that in the Craig section, three nights were used for marking fish, and in the Cascade section, two boats were used for two nights of marking and two nights of recapture effort on each bank.

Population estimates were calculated for all trout using the Modified Petersen's estimator or the partial log-likelihood estimator with the MFWP FA+ statistical software program. After all fish were estimated, only those measuring 10 inches long and greater were reported because of the inherent difficulties in sampling small trout in the Missouri River. Many trout in this portion of the Missouri River spend their first year in tributaries and were not available for inclusion in the estimates. Biologists assume that trout 10 inches long have recruited into the Missouri River population.

Other fish species were encountered incidental to the trout population estimates including mountain whitefish, white sucker, longnose sucker, walleye, burbot, carp, yellow perch, kokanee, longnose dace, brook trout and sculpin. Counts were made only of walleye, burbot, kokanee, brook trout and yellow perch. Walleye numbers were too low to calculate population estimates, so the number of walleye sampled each were used to compare with the average number of walleye caught over the period of record as well as the range of walleye caught. Walleye length data were analyzed using Fishers F test to test for equality in variances between the spring and fall sampling periods. The assumption was that fall sampling would yield a higher number of small fish than during the spring sampling. Length data were analyzed with two-sample t-tests assuming unequal variances (α=0.05).

Walleye have been present in Hauser and Holter reservoirs since the stocking of Lake Helena in 1951. Hauser Lake has been stocked with walleye intermittently since 1989. A walleye fishery has been present in Holter Lake for over 30 years. Walleye were first sampled in Canyon Ferry Reservoir (CFR) in 1989 and incidental occurrences persisted over the following 6 years (Yerk 2000). In 1994 young of the year (YOY) walleye first appeared in CFR during beach seine surveys when 2 were sampled. In 1997 walleye reproduction increased and 17 YOY walleye were sampled (Figure 7). From 1994 to 2011 the mean number of YOY walleye sampled in CFR was 33 (range 2-192). Over the period of record there have been changes in the number of walleye sampled in the Missouri River below Holter Dam. Up to 1995, mean number of walleye sampled in the Craig section during the spring was 6.5 per year. From 1996 through 2011 the mean number of walleye sampled increased to 15.2. During fall sampling up to 1995, the mean walleye catch 2.5 per year and from 1996 through 2011 the mean catch increased to 35.2 per year (Figure 4).

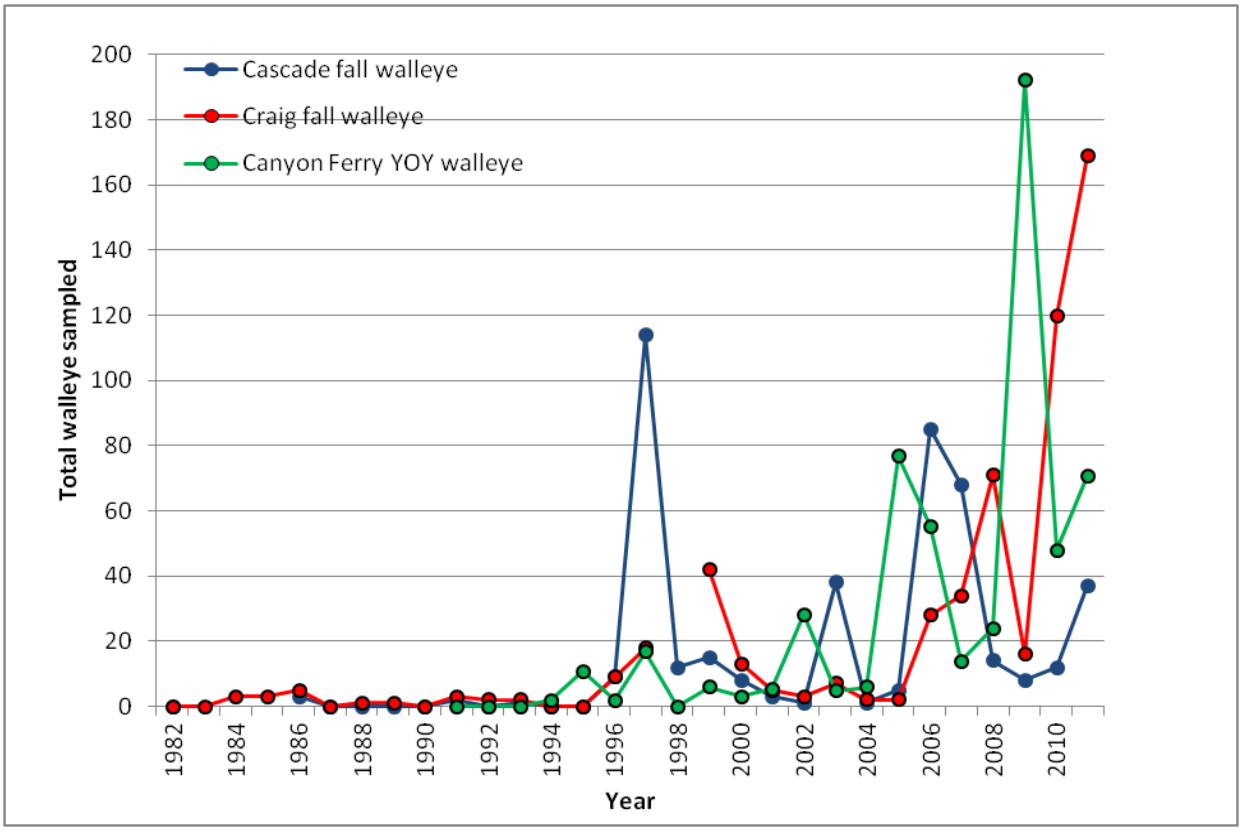

Figure 4. Total walleye caught per year in the Cascade and Craig sections during fall electrofishing and in Canyon Ferry Reservoir seine hauls.

In the Craig section, during brown trout estimates in the spring, walleye were sampled in 23 of 30 years. The mean number of walleye sampled was 12 (range 1-43) (Figure 5). The highest number was 43 which occurred in 2009. During rainbow trout estimates in October, walleye

were sampled in 23 of 30 years. The mean number of walleye sampled was 24 (range 1-169). The highest number was 169 which occurred in 2011 (Figure 6).

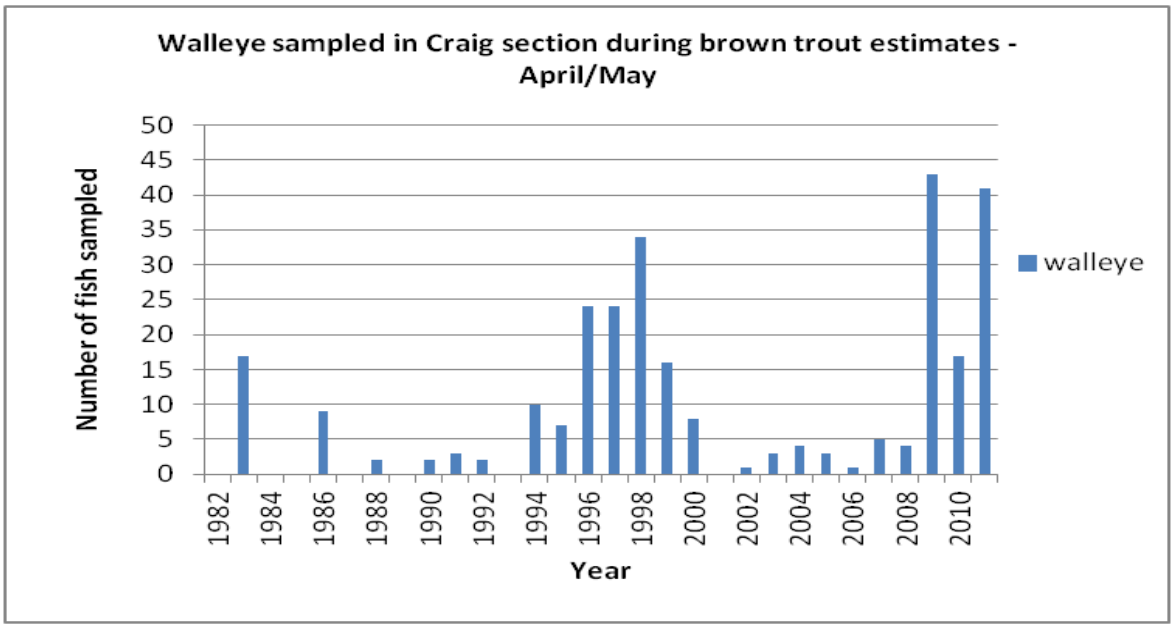

Figure 5. Number of walleye sampled in the Craig section by electrofishing during annual brown trout population estimates. Missouri River, Montana, 1982-2011.

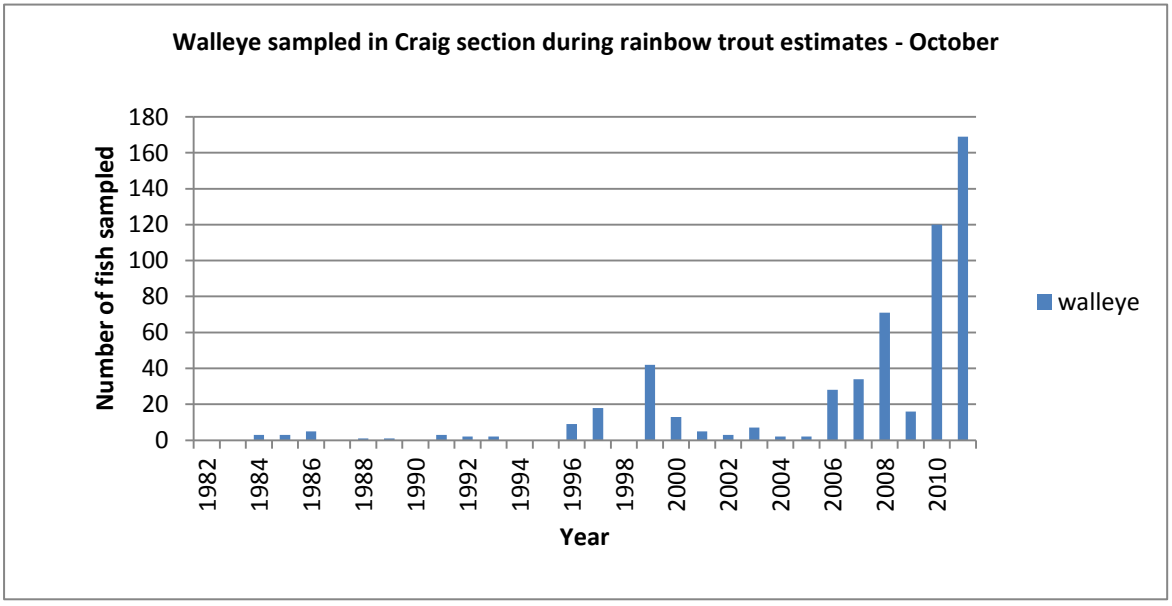

Figure 6. Number of walleye sampled in the Craig section by electrofishing during annual rainbow trout population estimates. Missouri River, Montana, 1982-2011.

In the Cascade section, during brown trout estimates in the spring, walleye were sampled in 9 of 27 years. The mean number of walleye sampled was 1 (range 1-4). During rainbow trout estimates in October, walleye were sampled in 20 of 28 years in the Cascade section (Figure 7). The mean number of walleye sampled was 22 (range 1-114). The highest number was 114 which occurred in 1997.

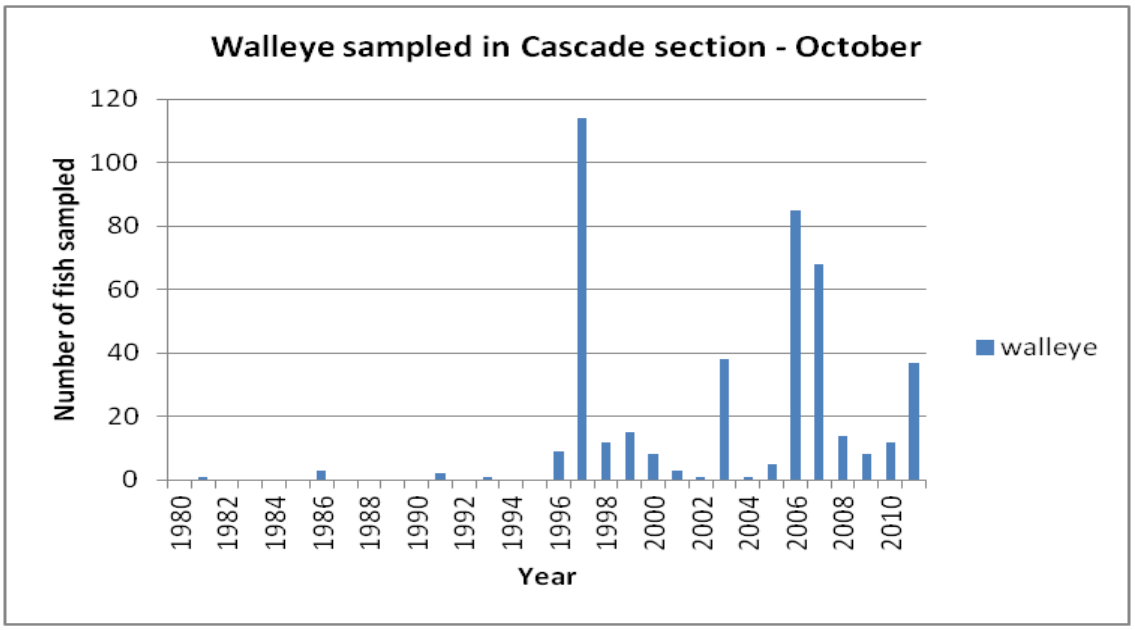

Figure 7. Number of walleye sampled in the Cascade section by electrofishing during annual rainbow trout population estimates. Missouri River, Montana, 1980-2011.

In the Cascade section in the spring, mean walleye catch up to 1995 was 1.0 per year and from 1996-2011 mean walleye catch was 1.5 per year. In the fall, mean walleye catch up to 1995 was 1.8 per year and from 1996-2011 mean walleye catch was 26.9 (Figure 7). A review of the October 1997 raw data from the Cascade section showed the mean length of walleye sampled was 6.4 (range 5.1-12.4) inches and only 4 of the fish sampled were greater than 8 inches. In 1997 peak flow of the Missouri River below Holter Dam was 23,500 cfs which was the 7th highest flow year over the 64 year period of record. On this basis, it appears as if high YOY walleye numbers in CFR in 1997 coupled with high flows in 1997 resulted in an increase in YOY walleye in the Missouri River Cascade section. This increase did not result in sustained high walleye numbers in the Missouri River because walleye numbers decreased in 1998, but were higher than the previous several years.

Over the period of record, there were a higher number of smaller walleye in Cascade section than the Craig section (Figure 8). Walleye sampled in the Cascade section in the spring were 47% longer than in the fall ($t(18)=7.24$, $P<0.05$). Mean length of spring walleye was 18.6 inches (range 9.0-28.4) and mean length of fall walleye was 8.7 inches (range 3.9-32.5). In the Craig section, walleye sampled in the spring were 30% longer than those sampled in the fall ($t(411)=14.3$, $P<0.05$). Mean length of spring walleye from the Craig section was 20.5 inches (range 5.4-32.3) and mean length of fall walleye was 14.1 inches (range 4.1-30.4). Overall, walleye mean length in the Craig section was 16.1 inches (range 4.1-32.3) and in the Cascade section it was 9.21 inches (3.9-32.5). The largest walleye from the Craig electrofishing section

was 30.4 inches long and weighed 12.9 pounds (October 2009) and in the Cascade electrofishing section, the largest walleye was 32.5 inches long and weighed 13.95 pounds (October 2011).

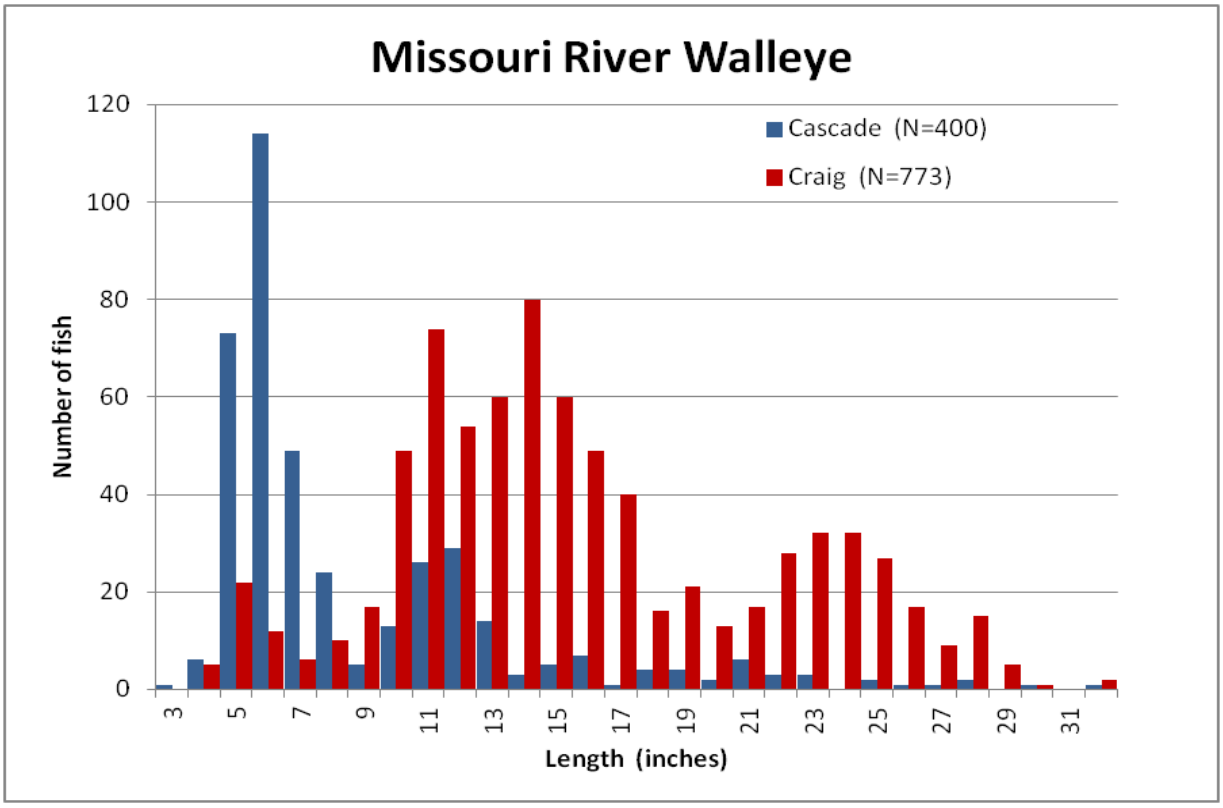

Figure 8. Length frequency distribution of walleye sampled in the Cascade section (1980-2011) and in the Craig section (1983-2011) of the Missouri River, Montana.

Tagging

Walleye were tagged using Floy brand FD-94 monofilament ¾ inch short –T anchor tags. Tags were green color with black lettering that read "RET. MT FWP" on one side with an index number such as "4-0000" on the other side. The number 4 denotes MFWP administrative region 4 and the four digit index number is unique to each tag. Tag color was coordinated within the region to reduce confounding management and research activities on various waters. Fish were tagged using a Mark II regular needle fabric tag gun. The gun needle was inserted on the left side of the fish near the posterior base of the spinous dorsal fin perpendicular to the longitudinal axis of the fish. This method allows the T anchor to catch between the spinous dorsal fin rays.

In 2008 we tagged 8 walleye in the Sun River near the 6th Street bridge incidental to another study evaluating trout movements between the Missouri, Smith and Sun rivers. Two of these tagged walleye (#906, #907) were harvested by anglers below Holter Dam within 6.5 months.

Based on the preliminary results we continued tagging walleye in the Sun River near the mouth each spring, near Bird Creek, and during the annual trout population estimates in the Craig section. Fish were captured using boat mounted electrofishing, trap nets, gill nets, trammel nets and angling. From 2008 through 2011 we tagged 389 walleye. A number of these tagged fish showed interesting movements;

Walleye #0906 was captured by trap net and tagged in the Sun River on March 25, 2008 0.6 mile upstream of the mouth. It was 13.6 inches long, weighed 0.76 pounds and its sex was undetermined. On December 12, 2008 (255 days later) this fish was harvested by an angler in the Missouri River 0.2 mile downstream of Holter Dam. Total distance traveled by this fish was 84.8 miles.

Walleye #0862 was captured by trap net and tagged in the Sun River on April 2, 2009 0.7 mile upstream of the mouth. It was 12.0 inches long, weighed 0.48 pounds and its sex was undetermined. On September 25, 2010 (541days later) this fish was harvested by an angler in the Missouri River 0.1 mile downstream of Holter Dam. Total distance traveled by this fish was 85.3 miles.

Walleye #0907 was captured by trap net and tagged in the Sun River on March 25, 2008 0.6 miles upstream of the mouth. It was 12.6 inches long, weighed 0.69 pounds and its sex was undetermined. On September 28, 2008 it was harvested by an angler in the Missouri River 0.5 miles downstream of Holter Dam. Total distance traveled by this fish was 84.4 miles over 191 days.

Walleye #0915 was captured by angling and tagged at river mile 43.2 in the Missouri River near the mouth of Little Muddy Creek on October 30, 2008. It was 22 inches long. No weight data were collected and its sex was undetermined. On October 14, 2009, this fish was harvested by an angler at river mile 84.7 in the Missouri River near the mouth of the Sun River. Total distance traveled by this fish was 41.5 miles in 349 days.

Walleye #0916 was captured by angling and tagged at river mile 43.2 in the Missouri River near the mouth of Little Muddy Creek on October 30, 2008. It was 18 inches long. No weight data were collect and its sex was undetermined. On April 18, 2011 this fish was harvested by an angler in the Missouri River 0.5 mile downstream of Holter Dam. Total distance traveled by this fish was 44.7 miles in 900 days.

Walleye #2035 was captured by trammel net and tagged at river mile 43.0 in the Missouri River downstream of Bird Creek on April 1, 2011. It was 16.7 inches long, weighed 1.7 pounds and its sex was undetermined. During an electrofishing survey on October 26, 2011 MFWP captured and released this fish in the Missouri River at river mile 84.5 near the mouth of the Sun River. Total distance traveled by this fish was 41.5 miles in 208 days.

As of December 31, 2011, the total angler harvest rate, based on tag returns, was 9.8% (*n*=38). Angler harvest of fish that were caught at the Holter and Great Falls sites was similar (9.8 and 6.1%, respectively). Fish tagged at the Cascade section had the highest (20%) tag return rate by anglers. Angler tag returns by month showed 55% of walleye tags were returned in the spring months (March, April, May) with 21% of the returns occurring in May (Figure 9). The majority (89%) of tagged fish that were harvested came from the 0.5 mile reach of the Missouri River

below Holter Dam and 5% came from each of the remaining two sites (Cascade, mouth of Sun River).

Apart from this tagging study, each year fishery workers responsible for the Holter Lake fishery, tag walleye to evaluate harvest rates and fish locations in the lake. Since 2007, 879 walleye have been tagged in Holter Lake (Troy Humphrey, MFWP, personal communication, 2011). The overall rate of return for Holter Lake tags from 2007-2011 was 26%. Of the 231 tags returned during this period, 18 (8%) of the fish tagged in Holter Lake were harvested in the Missouri River below Holter Dam. In 2011 fishery workers tagged 250 fish in Holter Lake with $75.00 reward tags to measure the level of angler capture of fish within the 20-28 inch "no harvest" length range. By the end of 2011, 125 of these reward-tagged fish had been captured/harvested and 8 (6.4%) of those fish were harvested from below Holter Dam. On this basis, it is clear that adult walleye were flushed through Holter Dam in 2011 and resided in the river downstream. On October 3, 2011 during the night electrofishing in the Craig section of the Missouri River fishery workers captured and released one reward-tagged walleye approximately 6 miles downstream of Holter Dam. The fish measured 14.5 inches long and weighed 1.12 pounds.

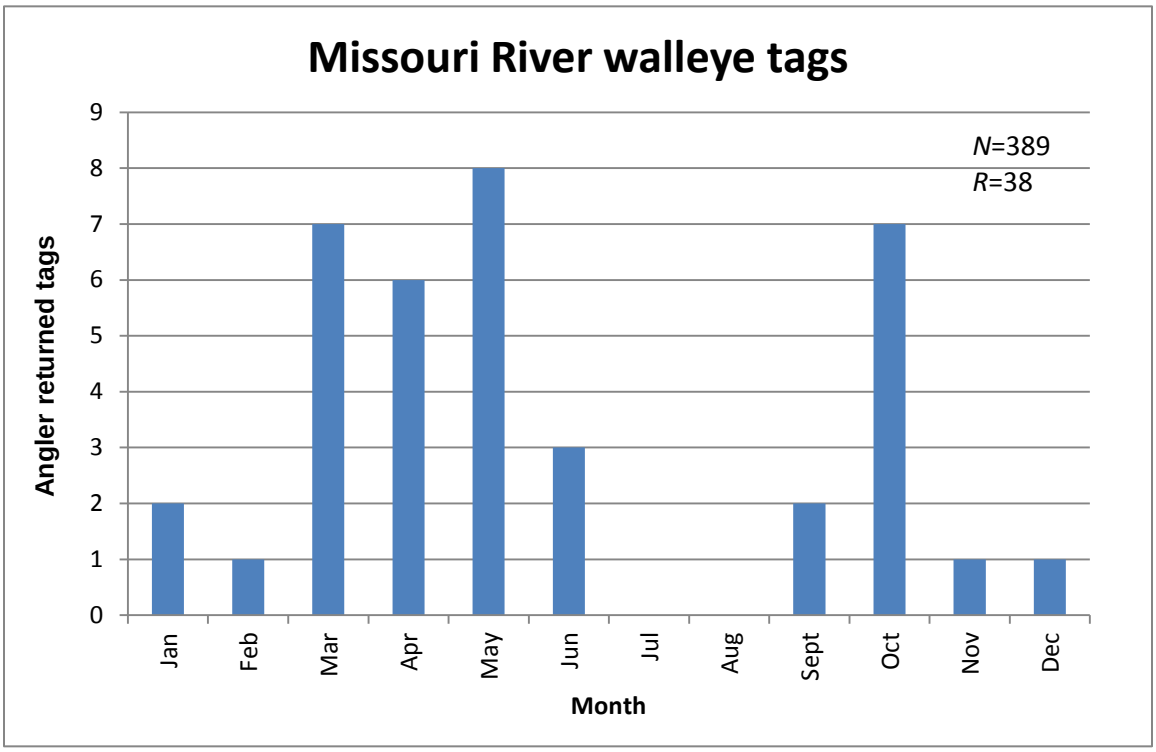

Figure 9. Walleye tag returns from the Missouri River, by month, 2008-2011.

Walleye tagging showed fish in this section are highly mobile. Fish tagged near the Bird Creek/Little Muddy Creek location disbursed both upstream and downstream and were harvested at the mouth of the Sun River and below Holter Dam. Fish tagged in the Sun River moved into the Missouri River and ascended 85 miles where they were harvested below Holter Dam. Passive monitoring of walleye proved to be a viable method of monitoring fish mobility and spatial harvest in this section of river.

Radio telemetry

From 2008-2010 we surgically implanted radio transmitters in 21 walleye to evaluate movements and behavior over multiple years. Radio-tagged fish were detected using a mobile radio-telemetry receiver (Lotek SRX 400 W5) and a truck, jet boat, or airplane. Stationary radio receivers (Lotek SRX 400 W7AS) were positioned at the mouths of the Sun River, Smith River, Sheep Creek, Dearborn River and Little Prickly Pear Creek, and at the Craig Bridge (Figure 1). Stationary receivers at creek mouths provided precise dates and times when fish passed by these locations.

We used a river mile reference system that assumes Holter Dam is river mile 0.0 and measurements continue downstream to Black Eagle Dam (Table 4). All fish locations were recorded to the nearest 0.1 mile. We used two sample t-tests (α=0.05) to test for differences in the mean distance traveled by males and females.

Table 4. Landmarks and associated river miles in the Missouri River between Holter Dam and Black Eagle Dam.

Landmark	River mile	Landmark	River mile
Holter Dam	0.0	End of Pelican Point electrofishing sxn	28.3
BLM Campground	0.3	Tintinger Slough	29.5
Wolf Creek Bridge	2.4	Mouth of Antelope Creek	30.6
Mouth of Little Prickly Pear Creek	2.7	Cascade Bridge	34.4
Inlet of Billings Slough	5.0	City of Cascade FAS	35.4
Inlet of Sterling Slough	6.9	Wing Dam	36.5
Mouth of Sterling Slough	7.4	Mouth of Bird Creek	41.4
Craig Bridge	7.9	Mouth of Little Muddy Creek	43.3
Jackson Rock	9.3	Castner Coulee	51.0
I-15 Bridge	10.3	Dunes FAS	53.1
Mouth of Stickney Creek	11.2	Ulm Bridge	56.4
Stickney FAS	11.7	Mouth of Smith River	58.1
Mouth of Dearborn River	13.5	Zahara Golf Course point	61.7
Mid Canon FAS	15.0	USGS Gaging station 06078200	66.8
Mouth of Andy Creek	17.7	Woodland Estates point	69.2
Devils Kitchen FAS	18.3	Big Bend FAS	75.0
Hardy Bridge	22.0	KMON Radio Towers	79.3
Prewett Creek FAS	22.3	Sand Coulee Creek	81.2
Chestnut Valley irrigation intake	22.4	White Bear Island	82.0
Mouth of Sheep Creek	22.7	Mouth of Sun River	84.7
Mouth Hardy Creek	24.2	Central West Bridge	85.7
Pelican Point FAS	26.2	Black Eagle Dam	88.5

Walleye 800-11 was captured by trammel net in the Missouri River 0.3 mile downstream from the mouth of Bird Creek on March 11, 2008. This fish was 21.2 inches long and weighed 4.2 pounds. It was surgically implanted with a radio transmitter and during the surgery it was positively identified as a male. Contact was lost with this fish for approximately 4 months until it was discovered 40.8 miles upstream, approximately 1.2 miles below Holter Dam. It spent most of the next year in the vicinity of Little Prickly Pear Creek mouth. On April 1, 2009 it was discovered upstream of the Cascade Bridge at river mile 34.3 and it stayed in this area for 5 days. On April 20 it moved upstream to river mile 29 near Tintinger Slough and stayed there through May 1. This fished moved back upstream and was detected by the remote receiver stations at the Dearborn River, Craig and Little Prickly Pear Creek. It resided near the mouth of the Dearborn River over the winter of 2009. In July 2010 it was located 1.2 miles downstream of Holter Dam and stayed in this area through October 25, 2010. From November 1 through 3, it traveled 21.5 miles downstream and was detected at the remote receiver stations at Craig and Sheep Creek only 24 hours apart. It was not located again. Based on movements during the 2009 spawning season, we believe this fish descended the Missouri River to spawn near Tintinger slough between April 20 and May 1. Other than its ability to make long distance movements in short periods of time, no other judgments can be made about the behavior of this fish. Overall, this fish traveled 153.6 miles in 967 days.

Walleye 890-13A was captured by angling in the Missouri River on October 30, 2008 at river mile 42.5 near Little Muddy Creek and was surgically implanted with a radio transmitter. It measured 17.4 inches long, 2.2 pounds and was positively identified as a male during the surgical procedure. This fish stayed in the general vicinity of Little Muddy Creek through April 15, 2009. On May 1 it was recorded 42.2 miles downstream at the mouth of the Sun River where it stayed for 18 days. It progressively moved upstream to the mouth of the Smith River, where it was recorded at the remote receiver station on June 14. It stayed at the mouth of the Smith River for 13 days. During a flight on September 18, it was discovered 29.8 miles upstream near the irrigation pump at the lower end of the Cascade electrofishing section. Based on significant movements during the 2009 spawning season, it is possible this fish spawned near the mouth of the Sun River. In 2009 this fish traveled 98.5 miles in 156 days. Overall, this fish traveled 155.3 miles in 323 days.

Walleye 800-12 was captured by trammel net in the Missouri River 0.3 mile downstream of Bird Creek on March 11, 2008. This fish was 28.5 inches long, weighed 11.8 pounds and was positively identified as a female. It was surgically implanted with a radio transmitter that was programmed to transmit for 6 months then rest for 6 months. Contact was lost with this fish within a few days of tagging. On March 21, 2009, it was caught and released by an angler in the same location it was tagged one year earlier (Figure 10). Over the next 48 days it progressively moved upstream 11 miles and resided at the island upstream of the Cascade Bridge from May 1 through 8. Two days later, on May 10, it was recorded 27.1 miles downstream by the remote receiver at the mouth of the Smith River. It stayed at the mouth of the Smith River for 50 days. On July 1 it was located in the Smith River 1.2 miles upstream from the mouth. Within one day it returned to the mouth of the Smith River where it stayed for 67 days until its radio turned off. In 2010, it was first discovered at the Cascade boat ramp on April 16. Over the next 2 days it progressively moved upstream 5.9 miles and resided near Tintinger Slough mouth for 2 days. On

April 28, 6 days later, it was recorded 28.5 miles downstream at the mouth of the Smith River where it stayed for four days. On May 5, it was located once again 28.5 miles upstream at the mouth of Tintinger Slough where it stayed for 5 days. It immediately returned to the mouth of the Smith River where it stayed for the remainder of the summer until its radio turned off on August 28. This fish displayed significant movements in 2009 and we believe it spawned at the island complex located upstream of the Cascade Bridge between May 1-8. In 2010 this fish showed significant movements in late April and early May and we believe this fish spawned near the mouth of Tintinger Slough near May 5. For 2 consecutive years, this fish was found at the deep hole located 0.3 mile downstream of Bird Creek in late March to early April. For 2 consecutive years it displayed significant movement during the spawning season in early May between Cascade Bridge and Tintinger Slough. This fish also showed its ability to travel long distances in short periods of time as well as an affinity for the mouth of the Smith River. The fact that it was located 1.5 miles up the Smith River also demonstrates limited use by walleye. Over a 900 day period of monitoring this fish traveled 97.5 miles.

Figure 10. Walleye 800-12 caught by an angler at river mile 41.6 on March 21, 2009. Note: radio antenna protruding from the abdomen.

Walleye 800-13 was captured by angling in the Missouri River near the mouth of Little Muddy Creek on October 30, 2008. This fish was 18.3 inches long, weighed 2.6 pounds and was

positively identified as a male. It was surgically implanted with a radio transmitter. Sixty-one days later, on December 31, it was recorded by the remote receiver at the mouth of the Sun River. It stayed in this area through May 6, 2009 until contact was lost. In October 2009 it was located again at the mouth of the Sun River where it stayed through April 17, 2010. During a flight on April 20, it was located 18 miles upstream at the UGSGS Ulm gage. One day later it was located 8.6 miles upstream at the mouth of the Smith River then contact was lost. On September 18, 2010 it was harvested by an angler 0.1 mile downstream of Holter Dam. This fish made a downstream movement to the mouth of the Sun River in the fall of 2008. The lack of communication in early May suggests it may have left the area to spawn. In was located at the mouth of the Sun River again in the fall of 2009. Upstream movements in April 2010 are suggestive of spawning behavior. This fish was harvested below Holter Dam in 2010. This fish demonstrated patterns of behavior that indicate a preference to reside near the mouth of the Sun River from late fall to early spring. It then made upstream movements during the 2009-10 spawning seasons. The fact that that it was harvested below Holter Dam indicates walleye are capable of using the entire 85 mile reach of river. Over the monitoring period, this fish traveled 126.8 miles in 688 days.

Walleye 800-14 was captured by angling in the Missouri River near the mouth of Little Muddy Creek on October 30, 2008. This fish was 21.3 inches long, weighed 4.6 pounds and was positively identified as a female. It was surgically implanted with a radio transmitter. Contact was lost with this fish over the next 6 months. On April 19, 2009 it was recorded 18.5 miles upstream by the remote receiver at Sheep Creek. Contact was lost through September 2009 until it was discovered during a flight at the Pelican Point FAS. Three days later (September 21) it was recorded 13.5 miles upstream by the remote receiver at the mouth of the Dearborn River. It moved upstream over the next 2 days and was recorded by the remote receivers at the Craig Bridge and at the mouth of Little Prickly Pear Creek. It stayed near the Little Prickly Pear Creek receiver for 58 days until contact was lost on November 20. The next contact of this fish was on May 23-24 at the mouth of the Smith River, 55.4 miles downstream. Beginning on September 17, 2010, this fish progressively moved upstream and was recorded on 1-2 day intervals at the remote stations at Sheep Creek, Dearborn River, Craig and Little Prickly Pear Creek. Its last location was 0.1 mile below Holter Dam on November 1, 2010. The general behavior of this fish suggests it made a spawning run in 2009 and likely spawned in the Missouri River between Sheep Creek and the Dearborn River. In 2010 it made downstream movements during May and may have spawned near the mouth of the Smith River. One of the more striking aspects of behavior displayed by this fish was for 2 consecutive years during the month of September this fish moved upstream from the Pelican Point area to Holter Dam. It traveled as much as 23.9 miles in 4 days in 2009 and 23.7 miles in 9 days in 2010. Overall this fish traveled 158 miles in 732 days.

Walleye 800-15 was captured by trammel net in the Missouri River 0.3 mile downstream of Bird Creek on March 13, 2008. This fish was 24.6 inches long, weighed 4.8 pounds and was positively identified as a male. It was surgically implanted with a radio transmitter. Contact was lost for nearly one year until this fish was discovered on April 20, 2009 at the island complex upstream of the Cascade Bridge. It stayed in this area through May 8 (18d). On July 1, 2009 it was located14.2 miles downstream in a deep hole near the Riverdale subdivision. Contact was lost for 293 days until it was located at the island complex upstream of the Cascade Bridge on

April 20, 2010. It stayed in this area through April 27 (7d). On July 2, 2010 it was located 17 miles downstream at Castner Coulee. Overall, this fish traveled 54.8 miles in 841 days. For two consecutive years this fish made migrations during the spawning season to the island complex upstream of the Cascade Bridge. We believe it spawned in this area between April 20 and May 8 during both years.

Walleye 800-50 was captured by trap net in the Sun River on April 1, 2009 0.7 mile upstream of the mouth. It measured 18.1 inches long, weighed 2.10 pounds and was conclusively identified as a male. It was surgically implanted with a radio transmitter. Over the next 443 (through June 18, 2010) days it stayed near the mouth of the Sun River and on 4 occasions it entered the Sun River traveling as far as 3.2 miles upstream. On June 23, 2010 it was recorded by the remote station at the Smith River. It progressively moved upstream over the next 48 days and was detected by the remote stations at Sheep Creek, Dearborn River, Craig and Little Prickly Pear Creek. Its last know location was at the Craig Bridge on August 11, 2010. A few judgments can be made about the behavior of this fish. It was located 2.7 miles upstream in the Sun River on May 12, 2009, which suggests it may have been making a spawning run. Almost daily records were made of this fish in May 2010 which showed it stayed in the vicinity of the remote station at the mouth of the Sun River. No conclusive judgments can be made about spawning, unless it spawned in this area. This fish also demonstrated long distance movements. In the summer of 2010 it traveled upstream 82 miles in the Missouri River in 54 days. Overall, this fish traveled 106.2 miles in 497 days.

Walleye 800-51 was captured by trap net in the Sun River on April 17, 2009 0.7 mile upstream of the mouth. It measured 17.8 inches long, weighed 1.17 pounds and was conclusively identified as a male. It was surgically implanted with a radio transmitter. Over the next 455 days this fish was detected at the mouth of the Sun River on 217 days. On July 30, 2010 this fish was detected at the mouth of the Smith River. It moved upstream 14.9 miles to the mouth of Little Muddy Creek on September 14, then returned to the mouth of the Smith River and stayed through October 12. The next day it was detected 26.6 miles downstream by the remote station at the mouth of the Sun River. It stayed in this location though April 11, 2011. Only 3 days later it was located 72.2 miles upstream in the Missouri River at the Spite Hill FAS. On May 18, it was located 10 miles upstream near the Wolf Creek Bridge. This fish remained at the mouth of the Sun River for 1.2 years before making several long distance journeys over short periods of time. It had prolonged stays at the mouth of the Sun and Smith rivers. In only 3 days it traveled 72.2 miles upstream in the Missouri River. Based on movements during the 2010 spawning period, we believe it spawned in the vicinity of the Wolf Creek Bridge near May 18. Overall, this fish traveled 222.4 miles in 761 days.

Walleye 800-52 was captured by trap net in the Sun River on April 17, 2009 0.7 mile upstream of the mouth. It measured 18.3 inches long, weighed 2.51 pounds and was conclusively identified as a male. It was surgically implanted with a radio transmitter. This fish stayed near the mouth of the Sun River for 32 days then progressively moved up the Missouri River to the mouth of the Smith River on June 17. On July 1 it was located 0.9 mile up the Smith River. It returned to the mouth of the Sun River on September 19 and stayed there through April 13, 2010. Over the next 71 days it progressively moved 72.5 miles upstream in the Missouri River eventually reaching the Spite Hill FAS on July 1. During this time it was located at the mouth of

Bird Creek on May 12, and we believe it may have spawned there near this date. Overall, this fish traveled 124.9 miles in 440 days.

Walleye 800-53 was captured by hoop net in the Smith River on April 22, 2009 1 mile upstream of the mouth. It measured 15.3 inches long, weighed 1.19 pounds and was conclusively identified as a male. It was surgically implanted with a radio transmitter. This fish stayed in the Smith River for 4 days. In one day it traveled 26.6 miles downstream and was detected by the remote receiver at the mouth of the Sun River. It stayed in this area for 13 days before contact was lost.

Walleye 800-54 was captured by trap net in the Sun River on April 13, 2009 0.7 mile upstream of the mouth. It measured 16.0 inches long, weighed 1.34 pounds and was conclusively identified as a male. It was surgically implanted with a radio transmitter. This fish stayed at the mouth of the Sun River through May 15. It progressively moved upstream in the Missouri River and was eventually harvested by an angler 0.1 mile below Holter Dam on October 12. In 150 days this fish traveled 84.5 miles upstream. It was located near the mouth of the Sun River between April 14 and May 15, but no judgments can be made whether it spawned there or not. Overall, this fish traveled 95.9 miles in 185 days.

Walleye 800-55 was captured by trap net in the Sun River on April 10, 2009 0.7 mile upstream of the mouth. It measured 16.0 inches long, weighed 1.34 pounds and was conclusively identified as a male. In 2009 this fish stayed in the lower 15.6 miles of the Missouri River between the mouth of the Sun River and Woodland Estates. In 2010, from March 6 through December 1 it progressively moved upstream in the Missouri River from the mouth of the Sun River to 0.1 mile below Holter Dam. It stayed below Holter Dam through April 14, 2011. On May 15, 2011, it was located 17.5 miles downstream near the mouth of Andy Creek. This fish displayed the ability to travel long distances in the Missouri from Great Falls to Holter Dam. In 2010 it made upstream movements in the Missouri River during the spawning season and was discovered at the Woodland Estates gravel pit on May 12. Movements during the 2011 spawning period suggests this fish descended the Missouri River to spawn near Andy Creek (RM 18) near May 15th. Overall, this fish traveled 134.1 miles in 762 days.

Walleye 800-56 was captured by trap net in the Sun River on April 13, 2009 0.7 mile upstream of the mouth. It measured 16.1 inches long, weighed 1.31 pounds and was conclusively identified as a male. It was surgically implanted with a radio transmitter. This fish stayed at the mouth of the Sun River through May 19th, and then rapidly moved 26.6 miles upstream to the mouth of the Smith River where it stayed for 2 days (May 23-24). It moved upstream 3.9 miles and stayed near the Monty Kuka house through September 18. It returned to the mouth of the Sun River on September 25 and moved between the Sun and Smith rivers through April 14, 2010. It began an upstream migration on April 15, 2010 and traveled 36.7 miles (just upstream of Castner Coulee) where it stayed for several days around May 12. It returned to the mouth of the Sun River on October 30 and displayed similar behavior as in 2009 where it moved intermittently between the Sun and Smith rivers through March 2011. Based on movements during the 2009 -10 spawning periods, we believe this fish may have spawned in the Missouri River near the mouth of the Smith River on May 23, 2009 and again at river mile 48 (upstream of Castner Coulee) near May 12, 2010. Overall, this fish traveled 160.6 miles in 709 days.

Walleye 800-57 was captured by electrofishing in the Missouri River on May 4, 2009 at river mile 5.0 near Billings Slough. It measured 21.2 inches long, weighed 3.08 pounds and was conclusively identified as a female. It was surgically implanted with a radio transmitter. It stayed in the same general vicinity for several days, then moved downstream and was detected by the remote receiver at the Craig Bridge on May 23. We believe it moved downstream to Jackson Rock and stayed there for several months. Weak radio performance suggests this fish was residing in the deep water pool at Jackson Rock. Several low altitude flights were made over this area, but the radio could not be coded and identified as #-57. No other conclusions can be made about this fish.

Walleye 800-58 was captured by trap net in the Sun River on April 10, 2009 0.7 mile upstream of the mouth. It measured 18.2 inches long, weighed 2.65 pounds and was conclusively identified as a female. It was surgically implanted with a radio transmitter. This fish stayed in the general vicinity of the Sun River mouth through February 27, 2010. It moved to the mouth of the Smith River on March 16 and stayed there for 30 days. It began an upstream migration in the Missouri River on April 17 and ultimately stopped at the island complex upstream of the Cascade Bridge on May 12. It progressively moved downstream and reached the mouth of the Sun River on September 19. It stayed in this area through May 9, 2011. This fish demonstrated migration patterns in 2010 consistent with spawning. We believe it spawned in the Missouri River at the island complex upstream of the Cascade Bridge on May 12, 2010. Overall, this fish traveled 102.4 miles in 759 days.

Walleye 800-59 was captured by trap net in the Sun River on April 10, 2009 0.7 mile upstream of the mouth. It measured 17.5 inches long, weighed 2.18 pounds and was conclusively identified as a female. It was surgically implanted with a radio transmitter. This fish stayed in the general vicinity of the Sun River mouth over the next 11 days. During a flight on May 5, it was located 3 miles upstream in the Sun River and returned to the mouth on May 14. On May 17 it began an upstream migration in the Sun River and was located 7 miles upstream on May 26. It progressively moved downstream to the mouth of the Sun River by June 4. Over the next 5 months this fish stayed in the lower 26 mile reach of the Missouri River and was located mostly at the mouths of the Sun and Smith rivers. It was harvested by an angler at the Warden Bridge near the mouth of the Sun River on November 21, 2009. Based on significant movements in May 2009, we believe this fish may have spawned in the Sun River at river mile 3 on May 1 or at river mile 7 on May 26. Overall, this fish traveled 52.4 miles in 255 days.

Walleye 800-62 was captured by trap net in the Sun River on April 10, 2009 0.1 mile upstream of the mouth. It measured 19.9 inches long, weighed 2.92 pounds and its sex was undetermined. It was surgically implanted with a radio transmitter. Over the next 7 months this fish traveled upstream and downstream in the 26 mile reach of the Missouri River between the mouth of the Sun River and Smith River. This fish was not located again after November 1, 2010. Notable location sites in the Missouri River included the lower end of Fisher Island, at river miles 80.5 – downstream of the KMON radio towers, and at the effluent of the Great Falls city water plant. No conclusions can be made about its behavior.

Walleye 800-54A was captured by trap net in the Sun River on April 6, 2010 0.1 mile upstream of the mouth. It measured 17.8 inches long, weighed 2.08 pounds and was conclusively identified as a male. It was surgically implanted with a radio transmitter. Over the next 8 months it progressively moved 41.6 miles upstream in the Missouri River, eventually reaching the mouth of Little Muddy Creek on December 2, 2010. It was not located again. No judgments can be made about its behavior. Overall, this fish traveled 41.6 miles in 240 days.

Walleye 800-59A was captured by electrofishing in the Missouri River on May 18, 2010 6.0 miles downstream of Holter Dam. It measured 23.5 inches long, weighed 4.13 pounds and was conclusively identified as a female. It was surgically implanted with a radio transmitter. Over the next 12 months this fish traveled both up and down stream in a 7.9 mile reach of river between the Craig Bridge and Holter Dam. It spent the winter of 2010 immediately below Holter Dam. On May 16, 2011 it was captured by MFWP during the marking run on the annual brown trout population estimate at river mile 4.2. An inspection at the time of capture indicates the fish had recently spawned as evidenced by having a flaccid abdomen. We believe this fish likely spawned in the Missouri River near RM 4.2.

Walleye 720-92 was captured by trap net and tagged in the Sun River on April 8, 2009 0.7 mile upstream from the mouth. This fish measured 18.7 inches long, weighed 2.57 pounds and was positively identified as a male during the radio implant surgery. It stayed near the mouth of the Sun River through May 3, and then progressively moved upstream in the Missouri River 84.2 miles, eventually stopping 0.5 mile below Holter Dam on September 18, 2009. It moved downstream to the mouth of Little Prickly Pear Creek and was detected by the remote station for 38 days. On November 27, it was detected by the remote station at the Craig Bridge. It was never located again. This fish started its upstream movement in the Missouri River on May 4, 2009. We detected it at river mile 78.2 (near KMON radio towers) on May 7, and again at river mile 81.6 (White Bear Island) on May 14. Based on movements during the spawning period, we can only speculate that it spawned in this area between May 7 and May 14. Over this time it traveled 92.5 miles in 233 days.

Walleye 720-93 was captured by trap net and tagged in the Sun River on April 8, 2009 at river mile 0.7. It measured 16.7 inches long, weighed 1.88 pounds and was conclusively identified as a male during the radio transmitter surgery. This fish stayed at the mouth of the Sun River for 448 days. In mid June 2010 it began an upstream migration of 76.7 miles in the Missouri River, eventually reaching the Craig Bridge on July 25. It stayed at the Craig Bridge for 91 days, then moved 7.9 miles upstream to Holter Dam. It stayed below Holter Dam for 163 days before it was harvested by an angler on May 13, 2011. No real judgments can be made about this fish other than its behavior of extended residence at the mouth of the Sun River, at the Craig Bridge and at Holter Dam. Overall, this fish traveled 84.6 miles in 765 days.

Throughout this study we made 1,196 relocations of radio tagged walleye. The mean number of relocations per fish was 57 (range 2-262). The mean distance walleye traveled during the surveillance period was 115.5 miles (range 41.6-222.4) (Table 5). Males traveled slightly longer mean distance (119 miles) than females (102 miles) but the differences were not significant (t (6) = 0.66, P =0.53). The mean number of days radios were monitored was 591 days (range 185-967). Eleven (52%) of the radio-tagged walleye showed burst-type movements by traveling long

distances in short periods of time. Mean rate of travel of these 11 walleye was 0.59 miles per hour (range 0.12 to 1.10 mph, median 0.43 mph). Four (36%) of the eleven walleye traveled between the mouth of the Sun River and the Smith River at a rate 1.1 miles per hour. The longest "burst" distance traveled by one of these fish was 72.2 miles in 72 hours.

In order to evaluate walleye behavior and establish patterns of use, we arranged the telemetry data according to location (river mile) and date to determine when an individual fish moved to a new site. Radio tagged walleye were located at 39 sites throughout the 85 mile reach of the Missouri River. Some patterns can be gleaned from the behavior of the 21 radio tagged fish we monitored. Walleye were surgically implanted with radio transmitters in the following proportions; 57.1% in the Sun River near the mouth, 28.6% at the Bird Creek-Little Muddy Creek location, 9.5% at the Craig location and 4.8% in the Smith River near the mouth. The top sites used most by radio tagged walleye are listed in Table 6, and reflect a higher proportion of use at sites with stationary receivers. The Smith River mouth was the site used most by radio tagged walleye (15.6%) and 71% of all radio tagged walleye used this site. The Sun River mouth was the site with the second highest use (14.3%) and 76% of the radio tagged walleye used the mouth of the Smith River. Although used less (6.5%) by radio tagged walleye, 38% of all radio walleye used the Holter Dam site.

Table 5. Meristics of radio tagged walleye in Missouri River, total miles traveled and total days radio transmitter was active, 2008-2011.

Fish ID	Length	Weight	Sex	Total miles traveled	Total days	Miles/d
800-11	21.2	4.20	M	153.6	967	0.16
800-12	28.5	11.8	F	97.5	900	0.11
800-13	18.3	2.60	M	126.8	688	0.18
800-14	21.3	4.60	F	158.0	732	0.22
800-15	24.6	4.80	M	54.8	841	0.07
800-50	18.1	2.10	M	106.2	497	0.21
800-51	17.8	1.17	M	222.4	761	0.29
800-52	18.3	2.51	M	124.9	440	0.28
800-53	15.3	1.19	M	---	---	---
800-54	17.9	2.10	M	95.9	185	0.52
800-55	16.0	1.34	M	134.1	762	0.18
800-56	16.1	1.31	M	160.6	709	0.23
800-57	21.2	3.08	F	---	---	---
800-58	18.2	2.65	F	102.4	759	0.13
800-59	17.5	2.18	F	52.4	255	0.21
800-62	19.9	2.92	---	---	---	---
800-54A	17.8	2.08	M	41.6	240	0.17
800-59A	23.5	4.13	F	---	---	---
720-92	18.7	2.57	M	92.5	233	0.40
720-93	16.7	1.88	M	84.6	765	0.11
890-13A	17.4	2.20	M	155.3	323	0.48

Table 6. Locations in the Missouri River and proportional use by radio tagged walleye 2008-10. Missouri River, Montana.

Site	Overall use by radioed fish
Holter Dam	6.5%
Little Prickly Pear Creek mouth	9.1%
Craig	7.8%
Dearborn River mouth	7.1%
Sheep Creek mouth	5.2%
Cascade Bridge	2.6%
Bird Creek to Little Muddy Creek	7.8%
Smith River mouth	15.6%
Sun River mouth	14.3%
total	75.9%

In the spring of 2009, the mean date of departure for radio-tagged walleye from the Sun River mouth was May 11 (range April 17-May 20). In the fall of 2009, 43% of all radio-tagged walleye returned to spend the fall/winter months at the mouth of the Sun River. Four of these walleye (800-52, 800-55, 800-56, 800-59) returned to the mouth of the Sun River between September 19 and October 16, where they spent the winter with five other radio-tagged walleye.

In 2010, the mean date of departure for radio-tagged walleye from the mouth of the Sun River was April 4 (range February 28-April 28). In the fall of 2010, 24% of all radio-tagged walleye returned to spend the fall/winter months at the mouth of the Sun River. Four of these fish (800-51, 800-56, 800-58, 800-62) returned to the mouth of the Sun River between September 19 and October 25, where they spent the winter with one other radio-tagged walleye. Only one radio-tagged walleye (800-56) returned to the mouth of the Sun River in the fall during both years.

In the spring of 2009 walleye 800-11, 800-12 and 800-15 were located in a 1.6 mile reach of river at the island complex upstream of the Cascade Bridge from April 1-May 1, May 1-8 and April 20-May 8, respectively. Two of these fish (800-12 and 800-15) returned to the same area again in 2010 along with another radio tagged walleye (800-58). These three fish were located at this site on April 20 and stayed for an average of 14d (range 7-22d). Based on our observations of multiple fish using this area during the spawning season in consecutive years, we determined that the 3.5 mile-long reach of river between Tintinger Slough outlet and the Cascade Bridge is used by walleye for spawning between April 1 and May 12. The physical features in this reach of river include two island complexes with large deep holes, long shallow side channels with low velocity water, numerous backwater areas with warmer water, and an abundance of gravel substrate which is suitable for spawning. Other probable spawning sites, based on movements of radio-tagged walleye during spawning seasons, include Missouri River mile 17.5 near Andy Creek, Missouri River mile 84.7 near the mouth of the Sun River, Sun River mile 3 and Sun River mile 7.

Radio tagged walleye demonstrated the ability to travel long distances in relatively short periods of time. Walleye 800-51 traveled 72.2 miles upstream in 3 days demonstrating a rate of travel of 1 mile per hour.

Early life history

There is compelling evidence that walleye numbers increased in the Missouri River below Holter Dam with the increases in walleye production in Canyon Ferry Reservoir in 1996-97. Comparing walleye catches during electrofishing in the Missouri River pre and post 1996 shows sustained elevated levels of walleye in the Missouri River below Holter Dam after the 1996 benchmark. There is also evidence of natural reproduction of walleye in this section of river. MFWP fishery crews sample post-spawn female walleye during the annual brown trout population estimates (Figure 11). Telemetry data showed three radio-tagged walleye congregated near Cascade during the spawning period in 2009 (Grisak 2010). In 2009 we began preliminary investigations in the Missouri River between Cascade and Great Falls to evaluate the status of young of the year (YOY) walleye in this section of river. The purpose was to provide information that could be used to make judgments about distribution and abundance of YOY walleye in this section of river.

The sampling protocol involved conducting 4 seine hauls at each site using a 4 foot tall by 25 foot long ¼ inch mesh common-sense minnow seine. We selected 11 sites between Cascade and Big Bend FAS (Table 7). These sites are best described as typical backwater areas or creek mouths with little to no water velocity and elevated water temperatures. We sampled 12 species of fish in 2009, 18 species in 2010 and 21 species in 2011 (Table 8).

In 2009, YOY walleye were distributed in backwater areas of the Missouri River over a 39.7 mile reach spanning from the Cascade boat ramp to Big Bend FAS. Walleye were sampled at six of the 11 sites. The two sites with the highest abundance of YOY walleye were the mouth of Bird Creek (n= 85) and the mouth of Little Muddy Creek (n=118). Mean length of YOY walleye was 58 mm (range 35-78).

In 2010 we removed 5 of the sites from the sampling list due to poor sampling conditions and added 6 new sites (Table 7). We conducted total counts of fish species up to ≈500 individuals, and for numbers greater than 500, we estimated the total number by species. In 2010, YOY walleye were distributed in select backwater areas over a 26.1 mile reach from the Cascade boat ramp to about 3 miles downstream of the Smith River mouth (Table 2). Walleye were most abundant in Little Muddy Creek mouth. We sampled 18 species of fish in 2010 compared to 12 species in 2009. We sampled YOY kokanee at sites # 2 and #8. Discussions with the Helena area biologist revealed kokanee were not stocked in the upstream reservoirs in 2010, which indicates these were wild kokanee produced by an increasing Holter Lake population, and likely spilled over Holter Dam during the high spring water flow.

Figure 11. A post-spawn female walleye captured during night electrofishing in the Craig section of the Missouri River, May 2010. Note the flaccid (indented) abdomen anterior to the urogenital pore.

In 2011, YOY walleye were distributed in backwaters over a 44.4 mile reach of river between the Wing Dam and the mouth of Sand Coulee Creek. The highest number of walleye (*n*= 36) were sampled at site 9 (RM 61.6). Compared to the two previous years, only trace numbers of YOY walleye were sampled at Bird Creek (*n*=2) and at Little Muddy Creek (*n*=6). In 2011, species richness increased to 21.

Over the three year period, walleye were sampled at 91% of the sites we sampled. Suckers (white, longnose) were the most abundant fish sampled. In 2010, suckers were found at 100% of the sites, carp were found at 92% of the sites, spottail shiners were found at 92% of the sites and walleye were found at 75% of the sites. In 2011, suckers were found at 92% of the sites, carp were found at 83% of the sites, spottail shiners were found at 67% of the sites and walleye were found at 58% of the sites.

Table 7. Young of the year walleye seined at sites in the Missouri River between Cascade and Great Falls.

Site	name	RM	2009 # walleye	2010 # walleye	2011 # walleye	Other species sampled
1	Cascade boat ramp	35.5	2	2	0	sucker, carp, lake chub, brown trout, rainbow trout, pumpkinseed sunfish, yellow perch, northern redbelly dace
2	Below Wing Dam	36.9	4	1	3	Spottail shiner, emerald shiner, kokanee, pumpkinseed sunfish, fathead minnow, sucker, carp, lake chub
3	Bird Creek mouth	41.4	85	11	2	Carp, yellow perch, spottail shiner, sucker, lake chub, emerald shiner, black crappie
4	Little Muddy ck mouth	43.2	118	179	6	Yellow perch, spottail shiner, pumpkinseed sunfish, emerald shiner, sucker, carp, longnose dace, northern redbelly dace, lake chub
5	Castner Coulee	50.7	---	2	0	Yellow perch, brown trout, golden shiner, spottail shiner, longnose dace, carp, sucker, fathead minnow, lake chub
6	Below Dunes FAS	54.2	---	14	10	Yellow perch, spottail shiner, fathead minnow, golden shiner, sucker, lake chub
7	0.5 mile into Smith R.	S-0.5	2	0	0	Spottail shiner, carp, sucker, pumpkinseed sunfish
8	Lord Ranch pt. below Smith	57.4	---	11	6	Kokanee, fathead minnow, carp, spottail shiner, pumpkinseed sunfish, sucker, flathead chub
9	Lower Lord Ranch point	61.6	---	15	36	Yellow perch, carp, flathead chub, spottail shiner, golden shiner, sucker
10	Across from Woodland Est	69.4	0	0	---	Stickleback, carp, spottail shiner, sucker, yellow perch
11	Across From Big Bend FAS	75.2	2	0	0	Sucker, carp, stickleback, spottail shiner, golden shiner, fathead minnow, flathead chub
12	Sand Coulee Creek mouth	81.3	---	0	3	Yellow perch, sucker, pumpkinseed sunfish, golden shiner, carp, spottail shiner, northern redbelly dace

Sites number 2 and 4 had the highest number (14) of species sampled. The average number of species sampled per site was 11 (range 8-14).

Walleye numbers in backwater areas were variable over the three year period. Little Muddy Creek mouth had the highest number of walleye in two of the three years (*n*=118 in 2009, *n*=179 in 2010) followed by Bird Creek mouth in 2009 (*n*=85) and lower Lord Ranch point in 2011 (*n*=36).

Table 8. Number of fish species sampled by year and total number of sites where found. Missouri River, Montana.

species	2009	2010	2011	# of sites where found
walleye	1	1	1	11
sucker	1	1	1	12
carp	1	1	1	11
lake chub	1	1	1	7
brown trout	1	1	1	6
rainbow trout		1	1	1
pumpkinseed sunfish	1	1	1	8
yellow perch	1	1	1	10
northern redbelly dace		1	1	3
spottail shiner	1	1	1	11
emerald shiner		1	1	3
kokanee		1		2
fathead minnow	1	1	1	7
black crappie	1	1	1	2
longnose dace	1	1	1	9
golden shiner		1	1	6
flathead chub	1	1	1	4
stickleback		1	1	4
mountain whitefish			1	5
hybognathus spp.			1	4
sculpin			1	2
black bullhead			1	1
number of species	12	18	21	---

Diet

In September 2010, Region 4 fishery staff responded to public comments provided during scoping for the 2011 proposed fishing regulation changes and agreed to evaluate the diet of walleye from the Missouri River below Holter Dam. We established a sampling protocol that involved spatial and temporal components by which sampling would be conducted during three time periods at three locations in the 85 mile reach between Holter Dam and the Great Falls. The three areas we selected to sample walleye for diet analysis were; 1) the 5.6 mile-long Craig electrofishing section near Holter Dam [upper], 2) the 2 mile reach between Bird Creek and Little Muddy Creek [middle], and 3) the 2.3 mile reach of the Missouri and Sun rivers between Taylor Island (Missouri) and the 6th street bridge (Sun River) [lower]. Past experience with capturing walleye for radio transmitter implants in this reach of river indicates a high amount of effort is required. Our protocol involved capturing 10 walleye from each section in April, July and October.

Walleye were captured using electrofishing, trap nets, trammel nets, gill nets and angling. We extracted walleye stomach contents using the gastric lavage technique which involved injecting a pressurized stream of water into the stomach and quickly withdrawing to create a rapid evacuation of the stomach contents into a container (Bellgraph et al. 2008). The stomach contents were preserved in formalin. Stomach items were sorted and identified to a reasonable degree of taxonomic resolution. In some cases stomach contents were digested beyond recognition or could only be identified to the generic level. We used Wilcoxon signed ranks tests to test for differences in percent occurrence of food items in walleye stomachs between the sampling periods (α =0.05).

Sampling during the summer period in 2011 was not possible due to very high flows in July. Mean flow at the Holter gage during July was 14,800 cfs (range 5,670-23,000). Electrofishing was the most productive method of capturing walleye and was 5.6 times more efficient than trap nets and 21 times more efficient than trammel nets (Table 9). Capture efficiency by gear type was localized in the study area. For example, passive sampling with trap nets in the Sun River was far more efficient than electrofishing. Conversely, active sampling with electrofishing was more efficient in the Craig location than any other method. Electrofishing was conducted during night time hours due to the sampling limitations in clear and shallow water.

Table 9. Capture rate by sampling method for walleye in the Missouri River, 2011.

Gear	Electrofishing	Trap net	Trammel net	Gill net	Angling
Fish	39	13	6	0	0
Effort	19.9 hrs	38 net days	64 drifts	12 hrs	8 hrs
Fish/unit	1.9	0.34	0.09	---	---

To identify fish (whole, partially digested fish, or pieces) in walleye stomachs we used a variety of metrics. For salmonids (trout and whitefish) we used melanophore characteristics, shape of mouth, spotting patterns on skin, cleithra configuration, pyloric cecae, vertebrae configuration, apaxial and hypaxial myomere coloration, tongue teeth, jaw teeth, and whole fish. For Catostomids (suckers) we use pharyngeal tooth counts, cleithra configuration, and whole undigested fish. For Cyprinids (minnows) we used phyringeal tooth counts, cleithra configuration, skull configuration and whole fish. Only one partial worm-type food item was discovered and identified to the sub-order level Oligochaeta based on segmentation features observed of the outer body wall.

Overall, 53% of the walleye stomachs we sampled had no contents and 47% had food items. Food items consisted of 99.6% fish and 0.4% worms. Fish in walleye stomachs were trout, brown trout, salmonid (trout or mountain whitefish), unknown fish, cyprinid (minnow species) and catostomid (sucker species). Cyprinid species included carp, spottail shiner, emerald shiner, longnose dace and fathead minnow. Catostomid species included white sucker and longnose sucker.

Salmonids were the food items most commonly (62.6%) observed in walleye stomachs, followed by catostomids (14.5%), unidentified food items (14.5 %), cyprinids (7.2%) and then Oligochaetes (1.2%) (Table 10). As a function of stomach contents by weight, Salmonids comprised the highest percentage (60.0%), followed by catostomids (27.9%), cyprinids (6.6%), unidentifiable food items (5.3%), then oligochaetes (0.1%) (Table 11).

Table 10. Percent occurrence of food items found in walleye stomachs from Missouri River, during spring and fall sampling periods, 2011.

	Lower				Middle				Upper				Total	
Species	Spring		Fall		Spring		Fall		Spring		Fall			
	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Undifferentiated Trout	---	---	---	---	1	20	---	---	---	---	5	45	6	7.2
Larval trout	---	---	---	---	---	---	---	---	42	86	---	---	42	50.6
Brown trout	---	---	---	---	---	---	---	---	1	2	2	18	3	3.6
Salmonid spp.	---	---	---	---	---	---	---	---	---	---	1	9	1	1.2
Catostomid spp.	3	23	1	33	3	60	1	50	3	6	1	9	12	14.5
Cyprinid spp.	4	31	---	---	1	20	---	---	---	---	---	---	5	6.0
Carp	---	---	1	33	---	---	---	---	---	---	---	---	1	1.2
Unidentifiable	6	46	1	33	---	---	1	50	2	4	2	18	12	14.5
Oligochaete	---	---	---	---	---	---	---	---	1	2	---	---	1	1.2

Table 11. Percent by weight of food items found in walleye stomachs from Missouri River, during spring and fall sampling periods, 2011.

Weight														
	Lower				Middle				Upper				Total	
Species	Spring		Fall		Spring		Fall		Spring		Fall			
	w	%	w	%	w	%	w	%	w	%	w	%	w	%
Undifferentiated trout	---	---	---	---	21.9	70.8	---	---	---	---	91.8	77.1	73.9	30.0
Larval trout	---	---	---	---	---	---	---	---	2.5	9.3	---	---	2.5	1.0
Brown trout	---	---	---	---	---	---	---	---	14.9	54.7	10.0	8.4	64.6	26.2
Salmonid spp.	---	---	---	---	---	---	---	---	---	---	6.9	5.8	6.9	2.8
Catostomid spp.	3.9	27.9	29.4	81.1	6.7	21.8	18.6	96.2	8.7	31.9	1.6	1.3	68.9	27.9
Cyprinid spp.	7.9	57.3	---	---	2.3	7.4	---	---	---	---	---	---	10.2	4.1
Carp	---	---	6.3	17.4	---	---	---	---	---	---	---	---	6.3	2.5
Unidentifiable	2.0	14.8	0.5	1.4	---	---	0.7	3.8	0.9	3.3	8.8	7.4	13.0	5.3
Oligochaete	---	---	---	---	---	---	---	---	0.2	0.8	---	---	0.2	0.1

Walleye stomachs sampled in the spring had a higher percent occurrence of food items than in the fall (Wilcoxon Z=-4.017, P= <0.01).

Catostomids were the only food item found in walleye stomachs at all three locations and during both sampling periods, with a slightly higher percent of occurrence in the fall than the spring (Wilcoxon Z=-2.201, P= 0.025). Salmonids were found in walleye stomachs mostly (98%) at the upper site and during both spring and fall sampling periods. The percent occurrence of salmonids in walleye stomachs was greater in the spring than in the fall (Wilcoxon Z=-2.201, P= 0.03). Only one walleye stomach sampled outside of the upper site contained a salmonid (unidentifiable trout) and was sampled from the middle site near the mouth of Little Muddy Creek. This stomach also contained a longnose dace. Cyprinids were found in walleye stomachs only at the lower and middle sites. Unidentifiable food items were found in stomachs at all locations during all sampling periods except for the spring period at the middle site.

Discussion

During the report period, we expended considerable effort sampling for walleye with gill nets, trammel nets, hoop nets, electrofishing and angling at numerous sites in an attempt to discover concentrations of walleye for tagging and diet studies. With the exception of the Craig and Cascade trout estimate sections, and the Holter, Cascade and Great Falls angling sites referenced herein, the only other locations where adult walleye were sampled included the lower 0.5 mile of the Smith River using hoop nets and immediately upstream of the Cascade bridge by trammel netting. The low capture success we observed throughout this study supports the evidence of low walleye population density and localized behavior.

Fixed-boom boat-mounted electrofishing was the most effective method of sampling walleye. Electrofishing was conducted primarily for estimating trout populations and walleye were

sampled incidentally. Electrofishing is not recommended as a primary means of sampling walleye between Holter Dam and Cascade due to the high level of trout by-catch. Night electrofishing was effective at sampling low numbers of walleye near the Sun River mouth in the fall. In the mouth of the Sun River, trap netting was an effective passive method of sampling walleye in the spring only. Trammel netting was the least effective, but was the only effective method of sampling walleye between Cascade and Little Muddy Creek. Night electrofishing may have been effective in this section, but operating a jet boat over 6 miles of river at night would be unsafe.

The increase in walleye production in Canyon Ferry Reservoir in 1994 appears to have resulted in an increase in walleye in the Missouri River below Holter Dam. Since 1996 walleye numbers increased in the Craig section 2.3 to 14.0 times the pre 1996 numbers. In the Cascade section walleye numbers increased 1.5 to 14.9 times the pre 1996 numbers.

Throughout the report period, 24% *(n*=5) of the radio tagged walleye used the entire reach of the Missouri River between the mouth of the Sun River and Holter Dam. Walleye were able to travel up to 1.1 miles per hour for 72 miles. Our results provided compelling evidence that walleye spawning occurs between the mouth of Tintinger Slough and the Cascade Bridge. Other probable spawning sites include: 1) RM 2.0 upstream of the Wolf Creek Bridge, 2) RM 4.2 near Bray Gulch, 3) RM 18 near Andy Creek, 4) the 11 mile reach of river between the Dearborn River and Sheep Creek, 5) RM 41.4 near the mouth of Bird Creek, 6) RM 58.1 near the mouth of the Smith River, 7) the 2.1 mile reach of river between RM 78.1 to 81.6 near the KMON radio towers, 8) RM 84.7 near the mouth of the Sun River, and 9) RM 3 in the Sun River. Walleye behavior at a number of these sites involved fish moving downstream during the spawning period. Studies of sauger and walleye in the Missouri River below Morony Dam showed 96% of radio tagged saugers and 57% of radio tagged walleyes migrated as far as 165 miles downstream to spawn (Bellgraph et al. 2008). The results of our tagging study showed 6.1% of the walleye tagged in the Sun River near the mouth were harvested by anglers below Holter Dam, which further indicates that walleye use the entire reach of river.

We found that 24-43% of the radio-tagged walleye returned to the mouth of the Sun River in the fall months and overwintered in this area through April. Our results indicate walleye behavior in the fall is likely driven by habitat and not forage. Habitat conditions in the lower portion of the study area include lower velocity water flow, lower gradient, higher turbidity, deeper pools, sandy substrate, and more large turbid-water tributaries (Smith, Sun) than in the upper portion. During electrofishing and trapping near the Missouri-Sun rivers confluence fishery workers observed and captured numerous fish from many species including trout, whitefish, suckers, carp, long nose dace, sculpin, spottail shiners and yellow perch. Grisak (2009, 2010) reported handling thousands of white suckers in the Sun River near the mouth during spring trapping. During this study we seined 9 species of fish in Sand Coulee Creek that are representative of the fish community in the lower portion of the study area and would be suitable forage for walleye.

Our results showed trout comprised 60% of overall walleye stomach contents with the proportions slightly higher in the upper section of the study area. This is not surprising considering trout are the most abundant fish in the upper reach. The presence of catostomids in walleye stomachs in the upper reach is surprising considering trout make up the overwhelming majority of fish in this reach of river. This suggests that walleye foraging in this area is likely opportunistic for soft rayed fish, irrespective of species.

Overall, 19% (*n*=4) of the radio tagged walleye were harvested by anglers. Three (75%) of these fish were harvested below Holter Dam and one (25%) was harvested near the mouth of the Sun River.

Young of the year walleye numbers in the Missouri River were variable between sites and between years. Missouri River peak water flow in 2011 (23,200 cfs) was nearly identical to 1997 (23,500 cfs) when high numbers of YOY walleye were sampled in the Cascade section during fall electrofishing. Despite similar peak flows between these two years, the total number of YOY walleye sampled in Canyon Ferry Reservoir in 1997 was 17 (0.28/net) and in 2011 was 71 (1.18/net). However, in 2011 we did not observe high numbers of YOY walleye in either the Cascade section or Craig section during electrofishing or during seining surveys between Cascade and Great Falls. There may be other factors not measured by this study that influence YOY walleye entrainment through the three dams. High flows in 2011 did translate to the highest number of adult walleye ever sampled in the Craig section during the fall. Holter Lake reward tags from walleye harvested below Holter Dam supports the evidence that higher than usual numbers of adult walleye flushed through Holter Dam in 2011.

The number of YOY walleye sampled by seining over the three year evaluation period appears to be in proportion with the number of adult walleye sampled during trout population estimates. High flows in 2011 provided ideal conditions to flush YOY walleye into the Missouri River. Seining did not detect unusually high numbers of YOY walleye in the Missouri River. Although not likely, it is possible that YOY walleye are flushed through the entire 88 mile reach. Despite annual variation in flushing rates of adult and YOY walleye, elevated levels of walleye in the Missouri River below Holter Dam from 1994-2011 suggests natural reproduction of walleye in upstream reservoirs has served to elevate levels of walleye in the Missouri River below Holter Dam.

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