Montana Fish, Wildlife & Parks

Trout and Whitefish Life History Study
2016 Update

Status Report for Northwestern Energy
FERC Project 2188

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Introduction

The timing of young rainbow trout outmigration from natal streams can have great influence on survival and year class strength (Biette et al. 1981; Rosenau 1991; Daugherty et al. 2003). In Montana's Holter Dam tailwater fishery a large portion of rainbow trout spend their first year in their natal streams then migrate into the Missouri River at age 1 (Munro 2004; Leathe et al. 2002; Leathe et al. 2014). In 1996, *Myxobolus cerebralis*, the parasite that causes whirling disease in rainbow trout, was discovered in the two most important spawning tributaries in this area. Despite a high prevalence of the parasite in these tributaries, no population impacts have been documented. In fact, the highest population densities have occurred after the discovery of *M. cerebralis* (Grisak and Tribby 2013). Recent studies have shown the lack of spawning site fidelity in adult rainbow trout as the likely mechanism that reduces the risk of impacts from this parasite by spreading the risk over spawning areas with a broad range of infection severity (Grisak et al. 2012).

PPL Montana (now Northwestern Energy) awarded Montana Fish, Wildlife and Parks (MFWP) $84,600 following the December 2013 Missouri River Technical Advisory Committee meeting to investigate trout and mountain whitefish life history characteristics and to bridge the information gap between previous studies.

The specific objectives of this study are to;

1. Compare outmigration timing with past studies (Leathe 2001),
2. Evaluate homing/straying from natal streams (Grisak et al. 2012),
3. Document level of straying over multiple years (Grisak et al. 2012),
4. Identify summer and winter locations of tagged fish in the Missouri River,
5. Use known age fish to evaluate historic ageing results and growth patterns over the past 31 years,
6. Identify connectivity of Missouri, Sun, and Smith River trout and whitefish populations.

To meet these objectives, Passive Integrated Transponder (PIT) technology is being used to monitor fish movement in the Missouri, Smith, and Sun river systems. Half duplex PIT tags were used with primarily 23 and 32 mm long tags to increase read range and tag detection efficiency. Most fish were tagged by making a small incision in the abdomen and placing the tag into the abdominal cavity. Fish movements are being monitored using a network of remote PIT tag monitoring stations and tracking with mobile antennae.

This project coincides with a corresponding trout and mountain whitefish life history study using PIT technology on the Smith River, which is being conducted by a graduate student at Montana State University (MSU). Given the ability of fish to utilize the entire Missouri, Smith, and Sun River system a great deal of coordination has been and will continue to be conducted between MSU and MFWP to maximize data collection and analysis efficiency. While the money awarded by Northwestern Energy was not utilized to conduct Smith River investigations, some Smith River results are reported here because of the interconnected nature of these studies. This report provides an update of the study through December 2016.

Methods

Remote Stations

To date, five remote PIT tag monitoring stations have been installed in the Missouri River drainage, three in the Sun River drainage, and fifteen in the Smith River drainage (Table 1; Figure 1). The five monitoring stations in the Missouri River drainage were installed spring 2014 and the three stations in the Sun River drainage were installed spring 2015. Many of the stations in the Smith River drainage were installed during summer 2014, with the remaining stations installed in 2015 and 2016 by the graduate student at Montana State University.

Efficiency of all Smith River readers at low flow were calculated in 2016 by M. Lance. To estimate efficiency of PIT tag detection, holes were drilled into Rapala fishing lures and a PIT tag was placed inside. Three sizes of tags (12, 23, and 32 mm), 2 directions, and 2 speeds were tested. Using a fishing pole, the lure was pulled upstream and downstream across the antenna at an approximate depth of 6 inches from the bottom to simulate a fish with a ventral PIT tag. A total of 40 passes were made with 10 downstream slow, 10 downstream fast, 10 upstream slow, and 10 upstream fast. The Rapala was kept parallel to the current and controlled for speed. A positive detection of the tag was based on an audible response from the pezio buzzer attached to the PIT tag reader. Detection efficiency was calculated by averaging the detection probability across each of the four replicates for a given tag size. The overall average detection probability for each tag size was calculated by summarizing all values across sites.

Mobile Tracking

Mobile tracking has been conducted using rafts, kayaks, and a backpack with a wand antenna to increase the number of detections and to determine fish locations in areas where remote monitoring stations are not present. Several mobile tracking trips were conducted on the Sun River and Missouri River in 2015. Numerous mobile tracking trips were conducted on the Missouri River in 2016 (5 complete trips from 16 Mar 2016 to 29 Sept 2016), using multiple antennae configurations in an effort to improve detection efficiency. These five trips scanned the Missouri River from Holter Dam to Pelican Point Fishing Access Site (FAS) (Figure 2).

A mobile backpack antennae was built in spring 2016 and used throughout the year for scanning American white pelican (*Pelecanus erythrorhynchos*) (hereafter, white pelican) nesting islands, tributary streams, and islands on the Missouri River from Holter Dam to Pelican Point FAS.

White pelican nesting locations were scanned for PIT tags to investigate avian predation on Missouri, Sun, and Smith rivers fish populations. PIT tags located at the white pelican nesting islands on Canyon Ferry and Arod Lake were assumed to be from white pelican depredation. A smaller number of cormorants also nested at these islands; however, the majority of the tags appeared to be located near white pelican nests. When scanning for PIT tags in the tributary streams it was noted if the tag was in a live fish or was no longer active (i.e., expelled or mortality). The lower 12.2 river miles (rm) of Little Prickly Pear Creek, 2.9 miles of Lyons Creek, 3.6 miles of Wolf Creek, and 2.8 miles of Sheep Creek were scanned. PIT tags located on islands on the Missouri River indicate the fish is no longer active due to mortality or tag expulsion.

Results

Fish Tagging

A total of 11,037 fish have been tagged in the Missouri, Sun, and Smith River drainages since 2010 (Tables 2, 3, and 4). Of these tags, 777 fish were tagged from 2010 through 2012 as part of the Tenderfoot Creek MSU graduate study. Of these 777 tagged fish, 362 have been redetected. In 2016, 61 fish tagged during the Tenderfoot study were detected 222 times. However, a substantial number of these 777 fish are likely no longer active in the system due to mortality.

In 2014, 7,801 fish were tagged, which comprises 71% of the total fish tagged from 2010 through 2016. In 2015, 1,835 fish were tagged and in 2016, 624 fish were tagged. Of the 624 fish tagged in 2016, 519 (83%) were tagged in the Smith River and 77 (12%) were tagged in Sheep Creek, a tributary to the Smith River. Twenty-one fish were tagged in the Missouri River, downstream of Ulm, including 15 burbot (*Lota lota*). Of the 11,037 fish tagged, mountain whitefish (*Prosopium williamsoni*), rainbow trout (*Oncorhynchus mykiss*) and brown trout (*Salmo trutta*) are the most tagged species, comprising 22%, 52%, and 21% of the tagged fish, respectively (Table 5).

The size distribution of fish tagged in the Missouri River drainage is shown in Figure 3. The majority of rainbow trout and brown trout tagged were less than 7 inches, whereas mountain whitefish were larger with most tagged fish between 14 and 19 inches (Figure 3). Proportionally, more large fish were tagged in the Sun River (Figure 4) than the Missouri River. In the Smith River, most brown trout tagged were between 5 and 9 inches while rainbow trout and mountain whitefish were larger (10 to17 inches) (Figure 5).

In the Missouri River drainage, the average mountain whitefish tagged was 14.8 inches (n=277), the average rainbow trout tagged was 7.0 inches (n=2,486), and the average brown trout tagged was 8.1 inches (n=633). In the Sun River drainage, the average mountain whitefish tagged was 12.5 inches (n=223), the average rainbow trout was 12.4 inches (n=153), and the average brown trout was 13.4 inches (n=353). In the Smith River drainage, the average mountain whitefish tagged was 11.7 inches (n=1,916), the average rainbow trout was 8.1 inches (n=3,137), and the average brown trout was 12.6 inches (n=1,278).

Detection Summaries

Missouri River drainage

A total of 3,572 fish have been tagged in the Missouri River drainage since 2014 (Table 2) with 930 of these fish redetected (26%) (Table 6). These redetections have occurred on the Missouri River tributary remote monitoring stations, by mobile tracking, or by scanning fish during population estimates on the Missouri. Of these 930 unique fish, 677 were rainbow trout (27.3% of total rainbow trout tagged), 83 mountain whitefish (29.9%), 121 brown trout (19.1%), 30 white sucker (29.1%), 18 longnose sucker (34.6%), and 1 burbot (5.8%) (Table 6). Nearly all of these tagged fish from the Missouri River drainage have remained within the Missouri River drainage (Table 7). However, one burbot tagged in the Missouri River downstream of Ulm was detected in the Smith River at the Truly Bridge reader in June 2016 and one rainbow trout tagged in the Missouri River at Broadwater Bay in Great Falls was detected in the lower Sun River near the town of Vaughn in July 2016.

Three hundred and seventy-seven fish have been tagged in Lyons Creek and 120 (95 rainbow trout, 25 brown trout) have since been redetected (31.8%) (Table 6). These 120 fish

have been detected a total of 640 times, with 570 detections occurring at the Lyons Creek reader, 8 at the Wolf Creek reader, and 62 at the Little Prickly Pear Creek reader (Table 7).

Of the 853 fish tagged in Wolf Creek, 204 (192 rainbow trout, 12 brown trout) have been redetected (23.9%) (Table 6). These 204 fish have been detected a total of 537 times, with 348 detections at the Wolf Creek reader, 9 at the Lyons Creek reader, 166 at the Little Prickly Pear Creek reader, 5 at the Dearborn River reader, 2 at the Sheep Creek reader, and 5 in the Missouri River mainstem (Table 7).

In Little Prickly Pear Creek, 619 fish have been tagged and 213 (179 rainbow trout, 29 brown trout, 4 white sucker, and 1 longnose sucker) have been redetected (34.4%) (Table 6). The 213 fish have been detected a total of 683 times, with 257 detections at the Little Prickly Pear Creek reader, 364 at the Lyons Creek reader, 40 at the Wolf Creek reader, 4 in the Missouri River mainstem near Craig, 9 at the Dearborn River reader, and 1 at the Sheep Creek (Missouri) reader (Table 7).

Of the 572 fish tagged in the Missouri River, 143 (33 rainbow trout, 39 brown trout, 51 mountain whitefish, 17 white sucker, 2 longnose sucker, and 1 burbot) have been redetected (25%) (Table 6). These 89 fish have been detected a total of 359 times, with 25 detections at the Lyons Creek reader, 20 at the Wolf Creek reader, 125 at the Little Prickly Pear Creek reader, 15 in the Missouri River mainstem near Craig, 153 at the Dearborn River reader, 4 at the Sheep Creek (Missouri) reader, 1 at the Smith River Truly Bridge reader, and 1 in the lower Sun River (Table 7).

In the Dearborn River, 655 fish have been tagged and 160 (99 rainbow trout, 6 brown trout, 32 mountain whitefish, 8 white suckers, and 15 longnose suckers) have been redetected (24.4%) (Table 6). These 160 fish have been detected a total of 646 times, with 14 detections at the Little Prickly Pear Creek reader, 625 at the Dearborn River reader, 5 at the Sheep Creek (Missouri) reader, and 1 in the Missouri River mainstem (Table 7).

Of the 498 fish tagged in Sheep Creek, 90 (79 rainbow trout, 10 brown trout, and 1 white sucker) have been redetected (18%) (Table 6). These 90 fish have been redetected 146 times, with 6 detections at the Little Prickly Pear Creek reader, 36 at the Dearborn River reader, 102 at the Sheep Creek reader, and 1 in the Missouri River mainstem (Table 7).

Sun River drainage

A total of 739 fish have been tagged in the Sun River drainage since 2015 (Table 3). Brown trout and mountain whitefish comprised the most fish tagged (47.7% and 30.1%, respectively). Of the 739 fish tagged, 150 unique fish have been redetected including 49 mountain whitefish (21.9% of whitefish tagged), 29 rainbow trout (18.9%), 70 brown trout (19.8%), 1 brook trout (33.3%) and 1 white sucker (14.2%) (Table 8).

Two hundred and twenty-three fish were tagged in the Sun River at the Hwy 287 site, and 107 (22 rainbow trout, 47 brown trout, 38 mountain whitefish) have been redetected (47.9%) (Table 8). The 107 fish have been redetected 468 times, with 467 detections in the Sun River near the Hwy 287 reader and 1 detected at the Elk Creek reader (Table 9).

One hundred and forty-two fish have been tagged in Elk Creek and of those, 16 fish (2 rainbow trout, 13 brown trout, and 1 brook trout) have been redetected (11.2%) (Table 8). These 16 fish were all from tagging on the Scherrer property on Elk Creek, and have been detected a total of 82 times with 80 detections occurring at the Elk Creek reader on the Scherrer property and 1 at the Sun River Hwy 287 reader. Of these 142 fish, 36 were tagged in Elk Creek near the confluence with Smith Creek and none of these fish have been redetected (Table 9).

Of the 173 fish tagged in the Sun River at the Simms site, 9 (2 rainbow trout, 4 brown trout, and 3 mountain whitefish) have been redetected (5.2%) (Table 8). These 9 fish were detected 25 times with 17 detections at the Sun River Hwy 287 reader and 7 (from 2 brown trout) at the lower Sun River reader located approximately 3 miles downstream of Largent Bent FAS (Table 9).

Of the 201 fish tagged in the Sun River at the site near the town of Sun River, 18 (3 rainbow trout, 6 brown trout, 8 mountain whitefish, and 1 white sucker) have been redetected (8.9%) (Table 8). These 18 fish were detected 23 times. Six of the 18 fish were detected by the lower Sun River reader, 2 mountain whitefish were detected by the upper Sun River Hwy 287 reader, and one rainbow trout was detected mobile tracking on the Sun River near the town of Sun River (Table 9).

Smith River drainage

A total of 6,726 fish have been tagged in the Smith River drainage since 2010 and 2,766 unique fish have been redetected (41.1%) (Table 10). These fish have been redetected 23,037 times with most detections occurring within the Smith River drainage (Table 11). However, several fish tagged in the Smith River drainage have been detected in the Missouri and Sun River drainages by remote reader stations. Two brown trout that were tagged on 1 July 2014 in Hound Creek (6.5 and 6.7 inches long when tagged), were detected at the Dearborn River reader on 24 Sept 2014 and 22 Oct 2014. Another brown trout that was tagged in Hound Creek on the same date and measured 7.4 inches long during tagging was detected at the Sheep Creek (Missouri) reader several times from 19 Mar 2015 through 3 April 2015. Lastly, a mountain whitefish (17.2 inches at tagging) that was tagged in Tenderfoot Creek on 24 July 2014 was detected at the lower Sun Reader on 21 Dec 2015.

A total of 100 unique fish have been detected at the lower most reader on the Smith at Truly Bridge approximately 9.1 river miles upstream from the confluence with the Missouri. Fish that were tagged in the Smith River drainage and detected at this reader could represent use of the Missouri River, as fish could move downstream into the Missouri River and remain there with a low chance of redetection. One hundred detections are a small amount compared to the number tagged in the Smith River; however, low read range at this reader could result in fish passing this reader without getting detected. For example, three of the four fish that were tagged in the Smith River and were detected in the Missouri and Sun River drainages were not detected at the Truly Bridge reader. In the efficiency trial in 2016, the Truly Bridge reader had a 35% (32 mm), 35% (23 mm), and 0% (12 mm) efficiency for detecting tags (M. Lance, MSU, unpublished data). This is in comparison to the mean efficiency of 88% (32 mm), 82% (23 mm), and 28% (12 mm) for all Smith River PIT tag antennas (M. Lance, unpublished data) (Table 12).

Pelican Predation

A total of 307 PIT tags were collected at Canyon Ferry Reservoir (CFR) and Arod Lake near white pelican nesting sites. Of the tags collected, 265 belonged to fish tagged in the Missouri, Smith, and Sun rivers (2.4% of the total number of tags) and 16 tags were from Big Hole River including one arctic grayling (*Thymallus arcticus*) (Table 13). Twenty-six tags that were unable to be matched to existing PIT tag databases and 1 FLOY tag from a channel catfish (*Ictalurus punctatus*) tagged on the Yellowstone River near Billings were also recovered.

Of the tags from our study collected at CFR, 110 were mountain whitefish (4.5% of total tagged mountain whitefish), 65 rainbow trout (1.1% of total tagged rainbow trout), 67 brown

trout (2.9% of total tagged brown trout), 3 white sucker (1.2% of total tagged white suckers), 1 longnose sucker (1.0% of total tagged fish), and 1 burbot (2.4% of total tagged burbot) (Table 13). These 247 tags represent 2.2% of the 11,037 tagged fish in the Missouri, Smith, and Sun drainages. Most of these tags (90.6%) were from fish tagged in the Smith River with mountain whitefish as the most common species (43% of recovered tags) (Table 12). The number of recovered PIT tags from rainbow trout and brown trout tagged in the Smith River was relatively equal (54 and 60).

Of the tags collected at Arod, 7 were mountain whitefish (0.28% of total tagged mountain whitefish), 3 were rainbow trout (0.05% of total tagged rainbow trout), 6 were brown trout (0.26%), and 2 were white sucker (0.79% of total tagged white sucker). These 18 tags are 0.16% of the 11,037 fish tagged from 2010-2016. Of these 18 tags collected, most fish were originally tagged in the Sun river drainage (56% of recovered tags).

Pelicans at Arod may be foraging more commonly on the Sun River but travel as far as Hound Creek (tributary to the Smith River) (Figure 6). Pelicans at CFR may be foraging more commonly on the Smith River but are traveling to the Dearborn River, Yellowstone River, and Big Hole River to forage (Figure 6). These surveys demonstrated that white pelicans from Arod Lake and CFR colonies travel up to 241 km (150 miles) to prey upon a variety of fish species (Figure 6). As the recovery rate of PIT tags is unknown, the total number of fish consumed within the Missouri, Smith, and Sun rivers by white pelican populations at CFR and Arod lakes are expected to be significantly more than the 265 tags we recovered.

Mobile Detections

Numerous mobile tracking trips were conducted on the Missouri River in 2016 (5 complete trips from 16 Mar 2016 to 29 Sept 2016), using multiple antennae configurations in an attempt to improve detection efficiency. These five trips scanned the Missouri River from Holter Dam to Pelican Point FAS (Figure 2). Despite these attempts mobile detections of fish in the mainstem Missouri River were infrequent ($\bar{x}$=2 fish per trip). Many mobile tracking trips have been conducted by MSU on the Smith River, resulting in numerous detections.

Of the 10 fish detected during 5 Missouri River mobile tracking trips, 7 were rainbow trout, 2 were brown trout and 1 was a mountain whitefish (Table 14). Most of these fish were originally tagged in the tributaries near to where they were redetected (Table 15).

In addition to the mainstem Missouri mobile surveys, four tributaries to the Missouri River were surveyed with a backpack PIT tag reader. Seven survey days from 27 July to 7 Sept 2016 detected 3 tagged fish (2 rainbow trout and 1 brown trout) and 92 shed tags (originally placed in 72 rainbow trout and 23 brown trout) (Table 16). Loose tags may be a result of tagged fish mortality or shedding.

Eight tags (from 2 rainbow trout, 6 brown trout) were detected in Sheep Creek with the backpack reader. All eight of these tags were from fish originally tagged in Sheep Creek (Table 17). In Wolf Creek, 3 tagged fish (2 rainbows and 1 brown trout) and 46 tags were detected (41 rainbow trout, 5 brown trout). Forty-seven of these 49 fish were originally tagged in Wolf Creek, 1 was tagged in LPP Creek, and 1 was tagged in the Missouri River (Table 17). Twenty tags (from 7 brown trout, 13 rainbow trout) were detected in Lyons Creek with 8 of these tags from fish originally tagged in LPP Creek and 12 tagged in Lyons Creek. In Little Prickly Pear Creek, 18 tags were detected (from 14 rainbow trout, 4 brown trout). Of these 18 tags, 10 were originally deployed in LPP Creek, 8 in Lyons Creek, and 1 in Wolf Creek (Table 17).

Discussion

In the Sun River drainage, the percentage of tagged fish that were redetected ranged from 0-47.9%. Of the fish tagged near the Hwy 287 (n=223), 47.9% were redetected. This high redetection may be due to those fish remaining near the location of their original tagging and having minimal movement throughout the drainage. Fish tagged at the Hwy 287 reader were redetected at the Hwy 287 reader 467 times within only 1 other detection occurring at the Elk Creek reader (Table 9). While most of the fish tagged at Hwy 287 were not redetected at other stationary readers, fish tagged in Sun River - Simms and the lower Sun River were detected at the Hwy 287 fixed reader. The Sun River has only 2 fixed readers over approximately 47.5 river miles, thus opportunities for redetection are low. The fact that several fish tagged in the Simms and lower Sun River sections were detected at the Hwy 287 reader, suggests fish could be seeking thermal refugia from warmer temperatures in the Simms and lower Sun River sections.

In the Missouri River drainage, the percentage of redetected tagged fish was relatively similar across tagging locations (18-34.4%) (Table 6). Movement patterns were similar across tagging locations and show dispersed movement across the drainage (Table 7). Unlike the Sun River drainage, fish tagged at locations throughout the Missouri River drainage were redetected at several other locations within the Missouri River drainage and not just at their original tagging location (Table 7). Fish tagged within Sheep Creek and the Dearborn River were redetected more often within their original tagging stream and were only detected at 3 other locations throughout the drainage (Table 7). This may be due to reduced movement of fish tagged in Sheep Creek and the Dearborn River or it may be due to the fish tagged in Sheep Creek having less opportunities to be redetected by other readers. Sheep Creek is approximately 10 river miles to the nearest reader (Dearborn) and approximately 21 river miles from the next closest reader (LPP Creek) within the Missouri River drainage. This is in comparison to readers on tributaries further upstream (Lyons Creek, Wolf Creek, and LPP Creek) which are approximately 3.3 to 10 river miles apart (Figure 1). Fish tagged in Sheep Creek had a redetection rate of 18% while fish tagged in Lyons, Wolf, and LPP Creek had redetection rates from 23.9 to 34.4%.

In the Smith River drainage, the percent of tagged fish redetected ranged from 15.3% to 49% (Table 10). Fish tagged in Hound Creek and Birch Creek had the lowest redetection rate (15.3% and 20%). Fish tagged in Hound Creek and Birch Creek were also detected most often within their original tagging locations (>89% of all detections) and were only detected at 3 other PIT tag readers (Table 11). The Smith River drainage has substantially greater opportunity for detection (15 readers) compared to the Sun River drainage (3 fixed readers) and the Missouri River drainage (5 readers) (Table 1). The Missouri River is much larger than the Smith River and we have no fixed readers on the Missouri River itself, nor have mobile detection efforts been productive on the Missouri River compared to the Smith River, further reducing the chance of detection in the Missouri River drainage compared to the Smith River drainage.

Redetection efforts may also be skewed by predation. The collection of PIT tags at CFR and Arod Lake, demonstrated that the Smith River drainage fish populations, including PIT tagged fish may experience heavy predation by white pelicans (Table 13). The Sun River may also experience heavy predation by white pelicans from Arod Lake. Several PIT tags from Missouri River drainage tagged fish were also recovered at CFR and Arod Lake, indicating some level of predation to this system as well. To further understand this predation impact on redetection and movement of PIT tagged fisheries in the Missouri, Sun, and Smith rivers, a predation study will be completed in 2017. This study will examine recovery rate of PIT tags at

white pelican nesting locations and will aim to estimate predation of PIT tagged fish in the Smith River.

From these detections of PIT tagged fish, the importance of connectivity and tributary health is clear. In the Missouri River drainage, Little Prickly Pear Creek and the Dearborn River have observed fish movement from fish tagged across the drainage. The LPP Creek fixed reader detected fish from all tagging locations in the Missouri River drainage and the Dearborn River recorded significant fish movement from across the drainage including fish tagged in the Missouri River, Lyons Creek, and LPP Creek. In the Smith River drainage, Sheep Creek and Moose Creek observed significant fish movement and had the most detections within the Smith River drainage (7,309 and 3,854 of 23,037, respectively).

Future analysis of movements of trout and whitefish populations in the Missouri, Smith, and Sun river drainages, may include estimates for detection effort, mapping of movement and detection over time, analysis of tag detection by year, and statistical calculations of the database.

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Figures

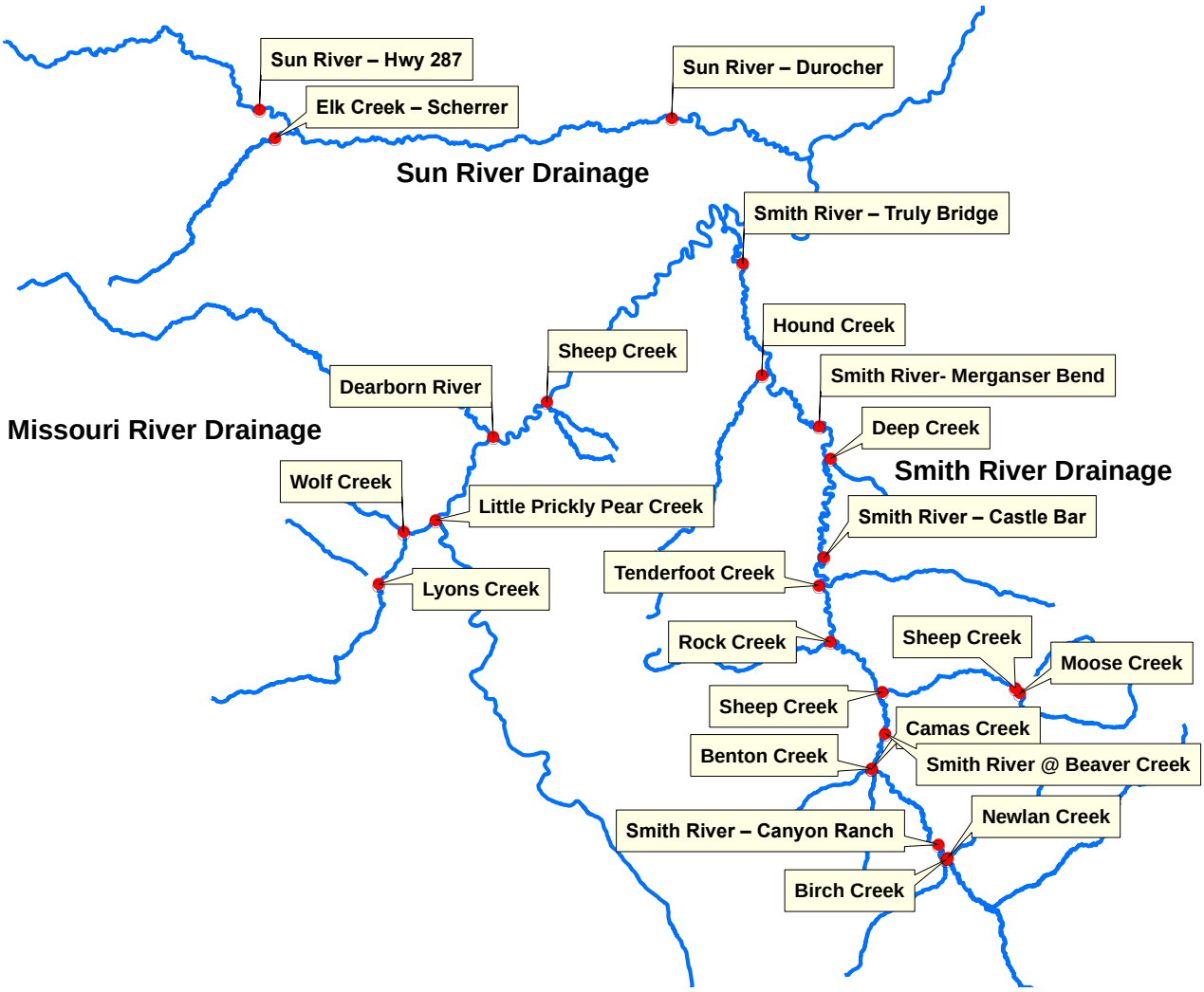

Figure 1. Map of fixed passive integrated tag (PIT) antennas in the Missouri, Smith, and Sun River drainages.

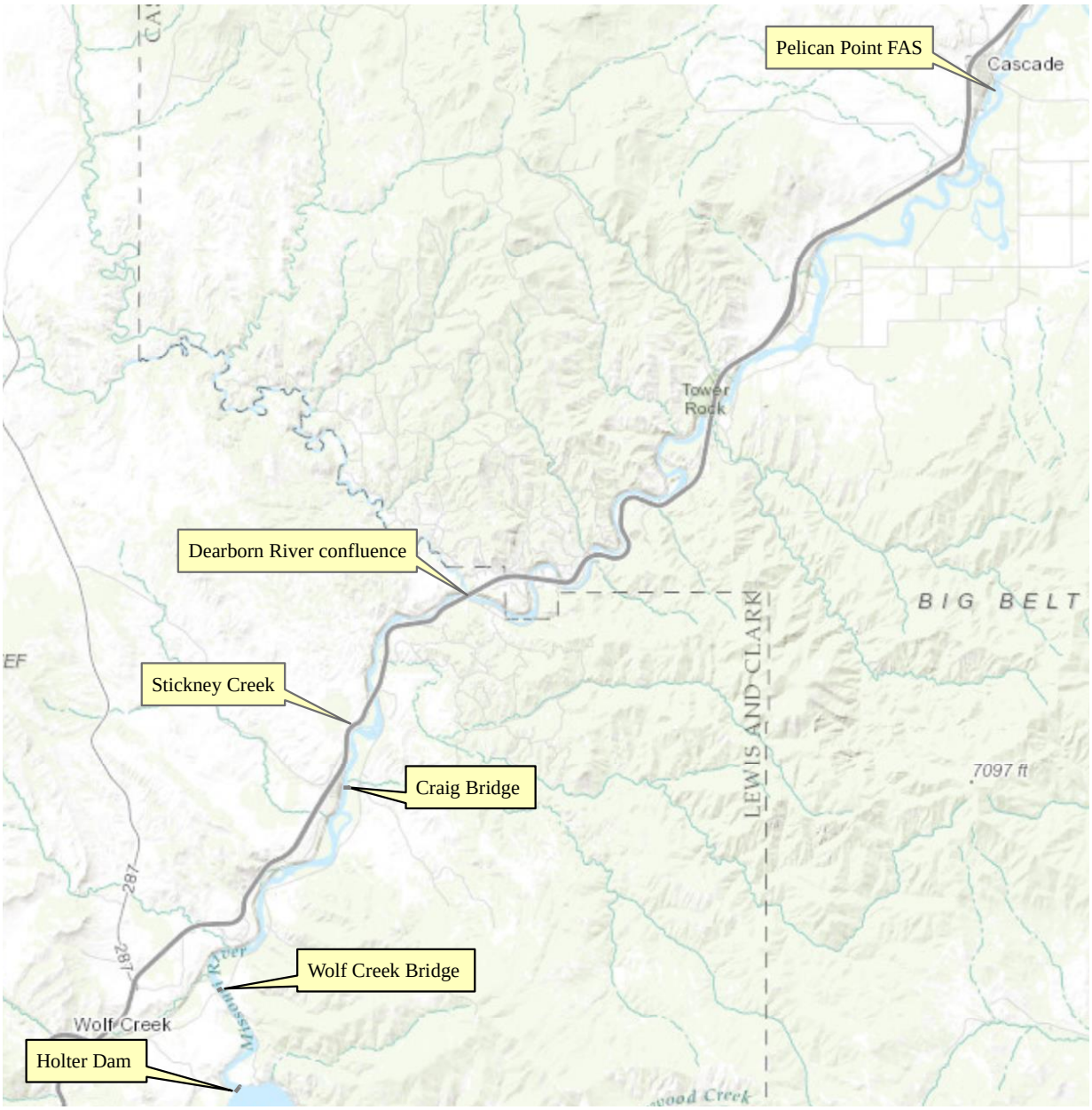

Figure 2. Sections of the Missouri River that were scanned in 2016 with a mobile PIT tag reader attached to a raft.

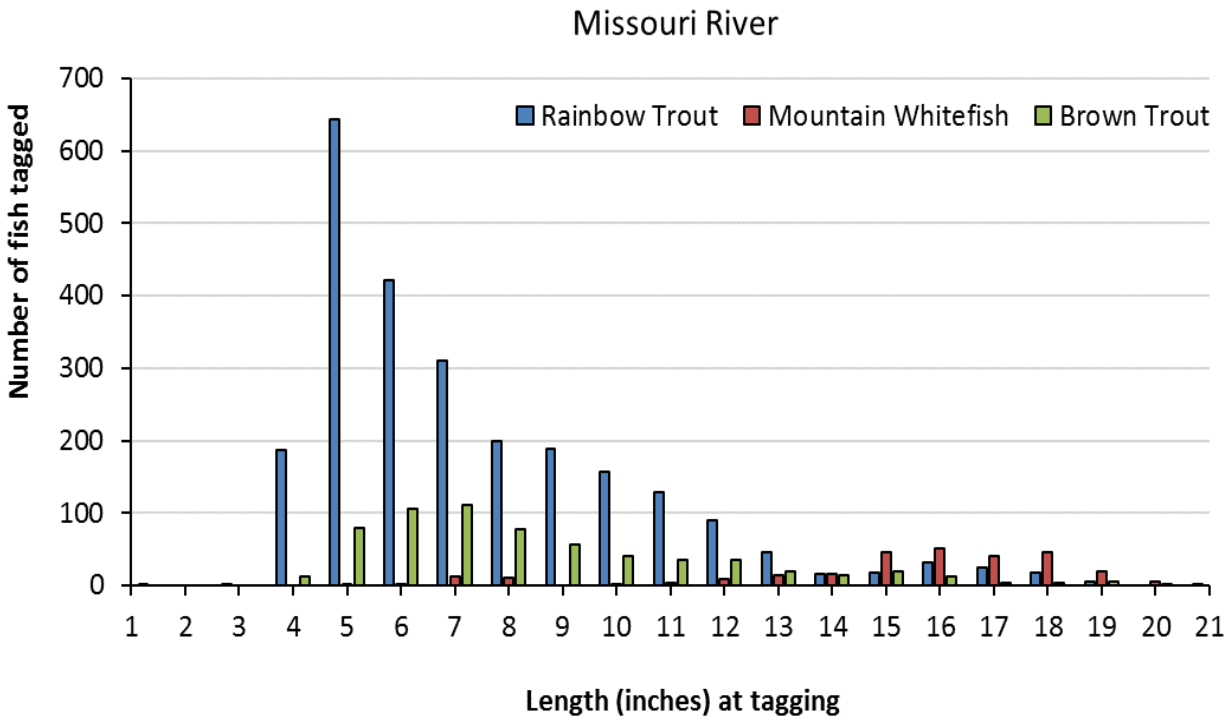

Figure 3. Size distribution of rainbow trout (*Oncorhynchus mykiss*), brown trout (*Salmo trutta*), and mountain whitefish (*Prosopium williamsoni*) tagged from 2014-2016 in the Missouri River drainage.

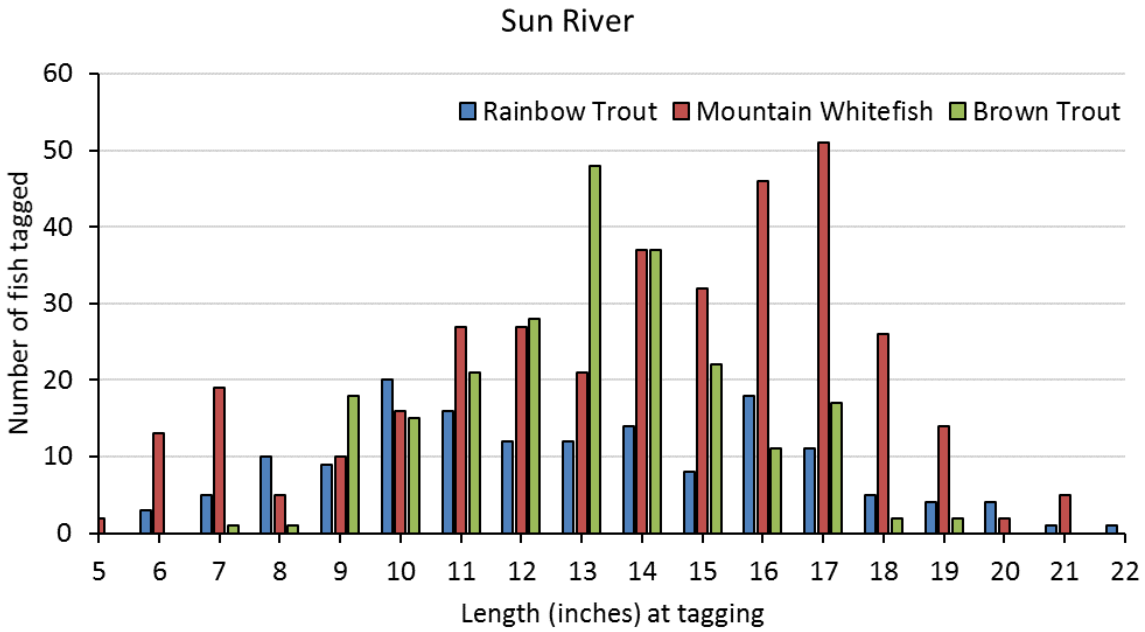

Figure 4. Size distribution of rainbow trout (*Oncorhynchus mykiss*), brown trout (*Salmo trutta*), and mountain whitefish (*Prosopium williamsoni*) tagged from 2015-2016 in the Sun River drainage.

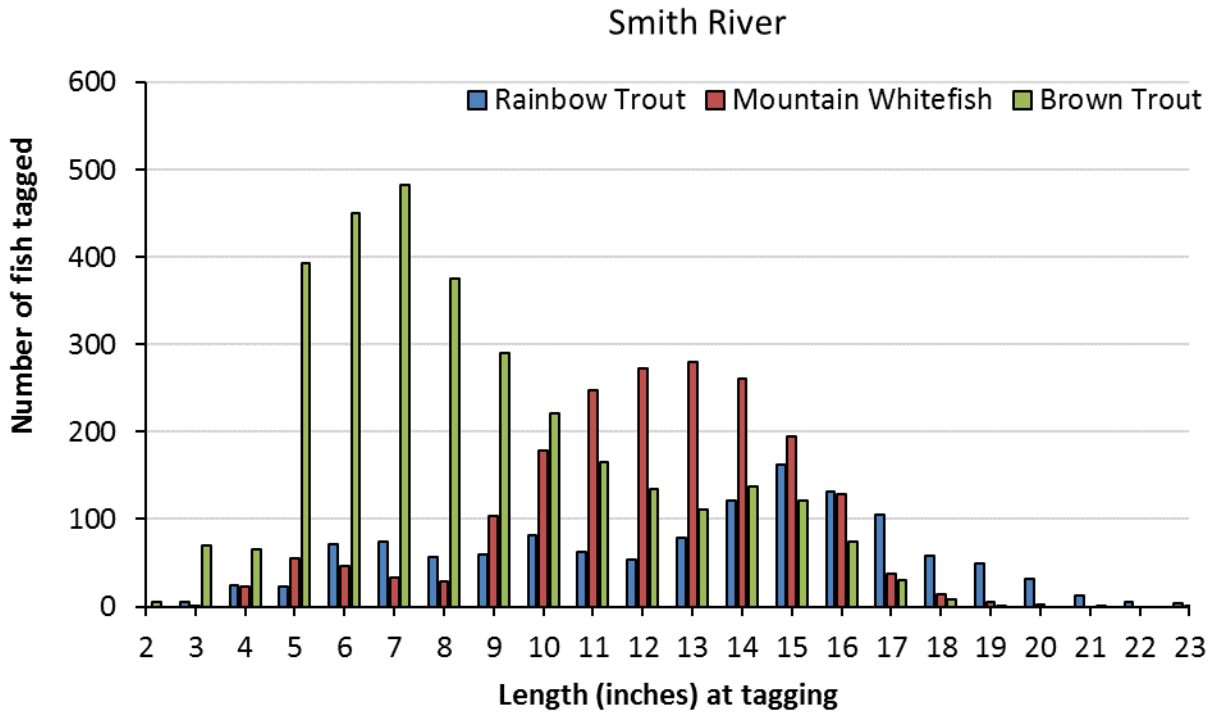

Figure 5. Size distribution of rainbow trout (*Oncorhynchus mykiss*), brown trout (*Salmo trutta*), and mountain whitefish (*Prosopium williamsoni*) tagged from 2010-2016 in the Smith River drainage.

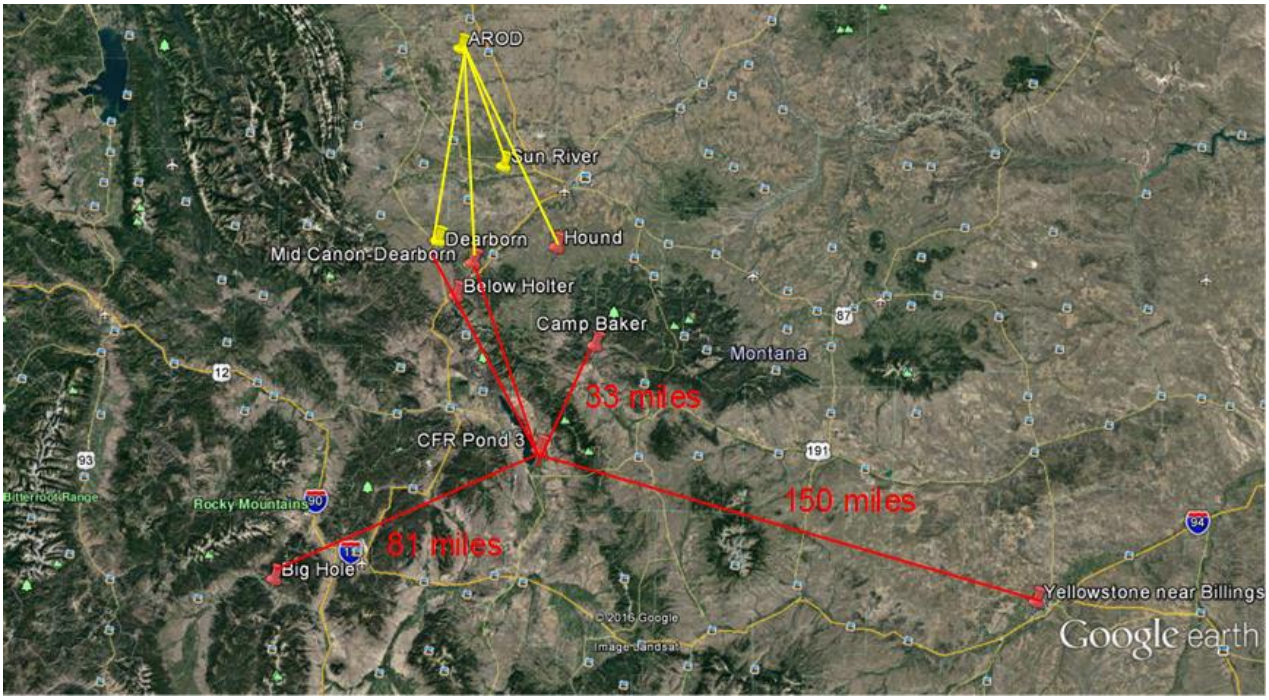

Figure 6. Original tagging locations of recovered PIT tags at American white pelican nesting locations on Canyon Ferry Reservoir, Montana (red) and Arod Lake (yellow). Depredated fish are assumed to have been consumed near the original tagging location. Associated foraging distance from nesting locations are attached.

Tables

Table 1. Remote station locations in the Missouri, Sun, and Smith River drainages arranged from upstream to downstream.

Drainage/ Stream	Lat	Long	Comments
Missouri River			
Lyons Creek	46.93827	-112.12581	Located just upstream of confluence with Little Prickly Pear Creek.
Wolf Creek	47.00597	-112.08026	Located just upstream of confluence with Little Prickly Pear Creek.
Little Prickly Pear Creek	47.02251	-112.02018	Located just upstream of confluence with Missouri River.
Dearborn River	47.13017	-111.91295	Located just upstream of confluence with Missouri River.
Sheep Creek	47.17681	-111.81165	Located just upstream of confluence with Missouri River.
Sun River			
Sun River – Hwy 287	47.54768	-112.36674	Located just upstream of Hwy 287 near Augusta at river 67.6.
Elk Creek – Scherrer	47.51229	-112.33641	Located at approx. river mile 2.8.
Sun River – Durocher	47.54413	-111.57848	Located upstream of Vaughn at river mile 20.
Smith River			
Birch Creek	46.58884	-111.05305	Located just upstream of confluence with Smith.
Newlan Creek	46.59094	-111.05070	Located just upstream of confluence with Smith.
Smith River – Canyon Ranch	46.60810	-111.06760	Located approx. river mile 107.
Benton Creek	46.70542	-111.19305	Located just upstream of confluence with Smith.
Camas Creek	46.70542	-111.19305	Located just upstream of confluence with Smith.
Smith River @ Beaver Creek	46.75143	-111.16839	Located at approximately river mile 87.5.
Moose Creek	46.80292	-110.91484	Located just upstream of confluence with Sheep Creek.
Sheep Creek	46.81047	-110.92272	Located approximately 0.6 miles downstream of Moose Creek.
Sheep Creek	46.80443	-111.17403	Located approximately 0.5 miles upstream of confluence with Smith River.
Rock Creek	46.86935	-111.27185	Located just upstream of confluence with Smith.
Tenderfoot Creek	46.94185	-111.29404	Located just upstream of confluence with Smith.
Smith River – Castle Bar	46.97789	-111.28427	Located at approximately river mile 60.3.
*Deep Creek	47.10581	-111.27255	Located just upstream of confluence with Smith.
Smith River-Merganser Bend	47.14734	-111.294	Located downstream of Merganser Bend campground
Hound Creek	47.21261	-111.40371	Located at approximately river mile 1.5.
Smith River – Truly Bridge	47.35658	-111.44140	Located at approximately river mile 9.1.

*****Deep Creek reader was removed in 2016 and placed in the mainstem of the Smith River at Merganser Bend.

Table 2. Number of tagged fish by species and waterbody in the Missouri River drainage from 2014 to 2016.

Tagging location	Mountain whitefish	Rainbow trout	Brown trout	Brook trout	White sucker	Longnose sucker	Burbot	Misc*	Total fish tagged
Dearborn River	46	390	131		40	46		2	655
Little Prickly Pear Creek	1	521	86		9	2			619
Lyons Creek		263	113		1				377
Missouri River	230	128	138		51	4	17	2	570
Sheep Creek		424	72		2				498
Wolf Creek		760	93						853
Total tagged fish	**277**	**2,486**	**633**	**0**	**103**	**52**	**17**	**4**	**3,572**

* Misc. = mountain sucker, yellow perch, and walleye.

Table 3. Number of tagged fish from 2015 to 2016 by species and waterbody in the Sun River drainage.

Tagging location	Mountain whitefish	Rainbow trout	Brown trout	Brook trout	White sucker	Longnose sucker	Burbot	Misc*	Total fish tagged
Sun River – Hwy 287	75	48	100						223
Sun River – Simms	64	55	54						173
Sun River – Sun River	81	41	74		5				201
Elk Creek – Scherrer		4	99	3					106
Elk Creek – at Smith Creek	3	5	26		2				36
Total fish by species	**223**	**153**	**353**	**3**	**7**	**0**	**0**	**0**	**739**

Table 4. Number of tagged fish from 2010 to 2016 by species and waterbody in the Smith River drainage.

	Mountain whitefish	Rainbow trout	Brown trout	Brook trout	White sucker	Longnose sucker	Burbot	Misc*	Total fish tagged
Smith R.	829	663	538	10	33	25	16	16	2130
Sheep C.	212	987	143	6	13	1	1	2	1365
Moose C.	271	906	6	21					1204
Tenderfoot C.	577	522	106	94					1299**
Hound C.	11	24	367		48	19			469
Newlan C.	5	1	21	13	45		7		92
Rock C.	17	13	68						98
Birch C.		6	50	11	2				69
Total fish tagged by species	**1,922**	**3,122**	**1,299**	**155**	**141**	**45**	**24**	**18**	**6,726**

* Totals include one mountain sucker tagged in the Smith River.

** 777 of the Tenderfoot tags are from David Ritter's graduate work and many of which are likely no longer active.

Table 5. Number of fish tagged in 2016 by species and waterbody. Below 2016 totals are total fish tagged from 2010-2016 by species and the percent that species composes of the 11,037 total fish tagged.

	Mountain whitefish	Rainbow trout	Brown trout	Brook trout	White sucker	Longnose sucker	Burbot	Misc*	Total Fish	% of 2016 total fish tagged
Smith River	185	151	149	7	7	12	5	3	519	83.1%
Sheep Creek	29	33	9	4			1	1	77	12.3%
Newlan C					2		5		7	1.1%
Missouri R.		4	1			1	15		21	3.4%
Total fish tagged in 2016	**214**	**188**	**159**	**11**	**9**	**13**	**26**	**4**	**624**	
Total fish species tagged 2010-2016	**2,422**	**5,761**	**2,285**	**158**	**251**	**97**	**41**	**22**	**11,037**	
Species percent of total fish tagged 2010-2016	0.219	0.521	0.207	0.014	0.022	0.008	0.003	0.002		

Table 6. Detections of unique PIT tagged fish in the Missouri River drainage. Fish were tagged from 2014 to 2016. Fish are organized by species and location of the original tagging.

Tagging location	Mountain whitefish	Rainbow trout	Brown trout	Brook trout	White sucker	Longnose sucker	Burbot	Misc*	Total unique fish detected	Total fish tagged	% redetected by tagging location
Dearborn River	32	99	6		8	15			160	655	24.4
Little Prickly Pear Creek		179	29		4	1			213	619	34.4
Lyons Creek		95	25						120	377	31.8
Missouri River	51	33	39		17	2	1		143	570	25.0
Sheep Creek		79	10		1				90	498	18.0
Wolf Creek		192	12						204	853	23.9
Total tagged fish detected	**83**	**677**	**121**	**0**	**30**	**18**	**1**	**0**	**930**	**3,572**	**26.0**
% tagged fish detected by species	**29.9**	**27.3**	**19.1**		**29.1**	**34.6**	**5.8**				

Table 7. Movement and detections of PIT tagged fish in the Missouri River drainage. Fish were tagged from 2014 to 2016 and are detected by fixed readers, mobile scanning, and electrofishing efforts. Detection data are organized by where the fish were originally tagged (rows) and where those fish have since been detected (columns). Arod and CFR are two nesting locations of white pelicans where digested PIT tags were discovered.

	Detection location										
Tagging location	**Dearborn R.**	**LLP C.**	**Lyons C.**	**Missouri R.**	**Sheep C.**	**Wolf C.**	**Smith R.**	**Sun R.**	**Arod Lake**	**CFR**	**Total detections**
Dearborn River	625	14		1	5					1	646
Little Prickly Pear Creek	9	257	364	4	1	40			3	5	683
Lyons Creek		62	570			8					640
Missouri River	153	125	25	15	4	20	1	1	2	13	359
Sheep Creek	36	6		1	102					1	146
Wolf Creek	5	166	9	5	2	348				2	537
Total detections	**828**	**630**	**968**	**26**	**114**	**416**	**1**	**1**	**5**	**22**	**3,011**

Table 8. Detections of unique PIT tagged fish in the Sun River drainage. Fish were tagged from 2015 to 2016. Fish are organized by species and location of the original tagging.

Tagging location	Mountain whitefish	Rainbow trout	Brown trout	Brook trout	White sucker	Longnose sucker	Burbot	Misc*	Total unique fish detected	Total fish tagged	% Redetected
Sun River – Hwy 287	38	22	47						107	223	47.9
Sun River – Simms	3	2	4						9	173	5.2
Sun River – Sun River	8	3	6		1				18	201	8.9
Elk Creek – Scherrer		2	13	1					16	106	15.0
Elk Creek – at Smith Creek									0	36	0
Total tagged fish detected	**49**	**29**	**70**	**1**	**1**	**0**	**0**	**0**	**150**	**739**	**20.2**

Table 9. Movement and detections of PIT tagged fish in the Sun River drainage. Fish were tagged from 2015 to 2016 and are detected by fixed readers, mobile scanning, and electrofishing efforts. Detection data are organized by where the fish were originally tagged (rows) and where those fish have since been detected (columns). Arod and CFR are two nesting locations of white pelicans where digested PIT tags were discovered.

	Detection location					
Tagging location	**Sun River – Hwy 287**	**Sun River – Simms**	**Sun River – Durocher**	**Elk Creek – Scherrer**	**Arod Lake**	**Total detections**
Sun River – Hwy 287	467			1		468
Sun River – Simms	17		7		1	25
Sun River – Sun River	5		10		8	23
Elk Creek – Scherrer	1			80	1	82
Total detections	**490**	**0**	**17**	**81**	**10**	**598**

Table 10. Detections of unique PIT tagged fish in the Smith River drainage. Fish were tagged from 2010 to 2016. Fish are organized by species and location of the original tagging.

Tagging location	Mountain whitefish	Rainbow trout	Brown trout	Brook trout	White sucker	Longnose sucker	Burbot	Misc*	Total fish detected	Total fish tagged	% Redetected
Smith R.	467	328	216	7	11	14	10	7	1060	2130	49.7
Sheep C.	138	268	37	4	5	1		1	454	1365	33.2
Moose C.	157	285	2	3					447	1204	37.1
Tenderfoot C.	421	177	42	7					647	1299**	49.8
Hound C.	5	2	42		19	4			72	469	15.3
Newlan C.	4	1	14		25		1		45	92	48.9
Rock C.	17	3	7						27	98	27.5
Birch C.		1	12		1				14	69	20.2
Total tagged fish detected	**1,209**	**1,065**	**372**	**21**	**61**	**19**	**11**	**8**	**2,766**	**6,726**	**41.1**

Table 11. Movement and detections of PIT tagged fish in the Smith River drainage. Fish were tagged from 2010 to 2016 and are detected by fixed readers, mobile scanning, and electrofishing efforts. Detection data are organized by where the fish were originally tagged (rows) and where those fish have since been detected (columns). Arod and CFR are two nesting locations of white pelicans where digested PIT tags were discovered.

	Detection location													
Tagging location	**Smith R.**	**Sheep C.**	**Moose C.**	**Tenderfoot C.**	**Hound C.**	**Newlan C.**	**Rock C.**	**Birch C.**	**Arod Lake**	**CFR**	**Camas Benton**	**Sun River**	**Dearborn**	**Total detections**
Smith R.	1,770	1303	20	334	144	1	68	302	1	141	160			4,244
Sheep C.	183	3,848	570	54	1	5	33	7		23				4,724
Moose C.	63	1,914	3,262	12			22	1		9				5,283
Tenderfoot C.	1,510	151	2	4,775	15		22	8		32		2		6,517
Hound C.	18	4			1,450				2	11			3	1,488
Newlan C.	10					120		63		1				194
Rock C.	30	89		19			90	4		3				235
Birch C.	7					25		315		5				352
Total	3,591	7,309	3,854	5,194	1,610	151	235	700	3	225	160	2	3	23,037

Table 12. Smith River PIT tag reader efficiency estimates calculated by M. Lance in 2016. Three tag sizes were tested moving upstream, downstream, fast and slow for a total of 40 replicates

	32mm	23mm	12mm
Min	0.28	0.18	0
Max	1	1	0.75
Mean	0.88	0.82	0.28
95% CI Low	0.77	0.69	0.13
95% CI High	0.99	0.95	0.43

Table 13. Collected PIT tags from white pelican nesting locations at Canyon Ferry Reservoir and Arod Lake identified to be from Sun, Missouri, and Smith river drainages. Tags were collected in 2016 and are organized by species and where the fish was originally PIT tagged.

Nesting location	Location fish was tagged	Mountain whitefish	Rainbow trout	Brown trout	White sucker	Longnose sucker	Burbot	Total
Canyon Ferry Reservoir	Missouri River Drainage	3	11	7		1		
	Smith River Drainage	107	54	60	3		1	
	Sun River Drainage							
Arod Lake	Missouri River Drainage	1	3		1			
	Smith River Drainage	1		1	1			
	Sun River Drainage	5		5				
Total from CFR		110	65	67	3	1	1	247
Collected tags at CFR to total tagged fish 2010-2016 by species		4.5%	1.1%	2.9%	1.2%	1.0%	2.4%	2.2%
Total from Arod Lake		7	3	6	2	0	0	18
Collected tags at Arod to total tagged fish 2010-2016 by species		0.28%	0.05%	0.26%	0.79%			0.16%
Total PIT tags collected		**117**	**68**	**73**	**5**	**1**	**1**	**265**

Table 14. Detections of PIT tagged fish in the Missouri River with a mobile PIT tag reader attached to raft.

Detection location	Rainbow trout	Brown trout	Mountain whitefish	Total
Holter-Wolf	2	1	1	4
Wolf-Craig	1			1
Craig-Dearborn	1			1
Holter-Stickney	1	1		2
Stickney-Pelican Point	2			2

Table 15. Original tagging locations of fish detected by in the Missouri River with mobile PIT tag reader attached to raft.

	Tagging location				
Detection location	**Sheep Creek**	**Missouri R**	**Dearborn R.**	**Wolf Creek**	**LPP Creek**
Holter-Wolf		2		1	1
Wolf-Craig				1	
Craig-Dearborn			1		
Holter-Stickney		2			
Stickney-Pelican Point	1	1			

Table 16. Detections of shed PIT tags and PIT tagged fish in tributaries to the Missouri River with a mobile PIT tag reader.

Detected PIT tags	Detection location	Rainbow trout	Brown trout	Total
Shed Tags	LPP Creek	14	4	18
	Lyons Creek	13	7	20
	Wolf Creek	41	5	49
	Sheep Creek	2	6	8
Tagged Fish	Wolf Creek	2	1	3

Table 17. Original deployment locations of PIT tags detected in tributaries to the Missouri River with a mobile backpack PIT tag reader.

	Tagging location				
Detection location	**LPP Creek**	**Lyons Creek**	**Wolf Creek**	**Sheep Creek**	**Missouri River**
LPP Creek	10	1	6		1
Lyons Creek	8	12			
Wolf Creek	1		47		1
Sheep Creek				8	