2016 Mill Creek LCM Station – Juvenile Coho Salmon Out-migrant Trapping Project, Smith River, California

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ANNUAL PROGRESS REPORT TO THE CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE
FISHERIES RESTORATION GRANTS PROGRAM
GRANTEE AGREEMENT: P1410547

ON BEHALF OF

THE SMITH RIVER ALLIANCE

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Annual Progress Report to the California Department of Fish and Wildlife
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Abstract

We used out-migrant trapping data to estimate the abundance of salmonid smolts emigrating from Mill Creek, Smith River (California) during the spring of 2016. We also estimated the apparent 2015-2016 overwinter survival probability of coho salmon (*Oncorhynchus kisutch*) marked in the fall of 2015 in Mill Creek and its two primary subbasins, East Fork Mill Creek and West Branch Mill Creek, using data collected by Mill Creek Lifecycle Monitoring Station partners. A rotary screw trap was operated in lower Mill Creek from the afternoon of March 16 through the morning of June 18, 2016. The trap was operational for all but two days over this 94 day period. Young-of-the-year Chinook salmon (*Oncorhynchus tshawytscha*) were the most numerous fish captured (114,797 individuals) followed by young-of-the-year trout (2,367 individuals). A total of 2,202 coho salmon smolts and 1,158 young-of-the-year coho salmon were captured in the rotary trap. A total of 2,576 steelhead (*Oncorhynchus mykiss*) and 1,470 coastal cutthroat (*Oncorhynchus clarki clarki*) were captured. Mark-recapture of fin clipped smolts and pre-smolts was used to estimate the abundance of coho salmon, steelhead, and coastal cutthroat trout emigrants passing the trap site. We estimated a total of 7,541 (SE=440) coho salmon smolt, 2,077 steelhead smolt (SE=469) and 2,447 coastal cutthroat trout smolt (SE=584) emigrants passed the Mill Creek out-migrant trapping site during the 2016 trapping season. We used Cormack-Jolly-Seber (CJS) mark-recapture models to estimate the 'apparent' overwinter survival and early emigration of coho salmon tagged in the fall of 2015 by using the recaptures at the rotary screw trap and three stationary PIT tag antenna arrays in Mill Creek. Apparent 2015-2016 overwinter survival, which does not account for individuals unavailable for capture due to early emigration, was estimated to be 10.6% (SE = 0.024) across all of the Mill Creek basin. In the two major Mill Creek subbasins (West Branch Mill Creek and East Fork Mill Creek) apparent overwinter survival during 2015-2016 was estimated to be 9.2% and 12.9% respectively. Twelve percent of coho salmon tagged in the fall of 2015 were detected leaving Mill Creek prior to the out-migrant trapping effort, suggesting significant numbers of coho salmon juveniles emigrated early.

Cover Photo: ***Mill Creek Lifecycle Monitoring Station rotary screw trap in operation.***
Photo taken by Justin Garwood,

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We would like to thank the California Department of Fish and Wildlife for its continued commitment to and support of all aspects of the Coastal Salmonid Monitoring Program in the Smith River basin including the Mill Creek Life Cycle Monitoring Station. The California Department of Fish and Wildlife was instrumental in the development and implementation of the out-migrant trapping portion of the Mill Creek Life Cycle Monitoring program through contributions from Sportfish Restoration Act funds. Among the many contributions to the Mill Creek Life Cycle Monitoring Station by the California Department of Fish and Wildlife include the rotary screw trap. Justin Garwood of the California Department of Fish and Wildlife worked tirelessly to get the Smith River and Mill Creek monitoring programs off the ground. We also wish to acknowledge the critical support provided by the Save the Redwoods League for their generous contributions toward fall tagging efforts necessary to better understand coho salmon survival and distribution in the Mill Creek Lifecycle Monitoring Station. A hearty shout out goes to all of the exceptional field biologists who collected rigorous field data: Sunny Bourdon, Tara Dettmar, Vimal Golding, Rachael McCain, Jesse Nolan and Marisa Parish, Zach Wenderott. We thank Mary Kuehner and Marisa Parish for administrative assistance throughout the study. We thank Patty McCleary and Grant Werschkull of the Smith River Alliance for their continued enthusiastic support for this project. Many thanks to Jeff Bomke of California State Parks for the opportunity of leasing park office and housing space at the "River House". Last, we would like to thank Redwood National and State Parks for providing critical access to all portions of Mill Creek and helping to make the Mill Creek Lifecycle Monitoring Station possible. Understanding salmonid distribution and abundance throughout this important basin remains essential to defining the status and trends of Smith River salmonid populations.

Introduction

In this brief progress report, we present estimates of 2016 out-migrating coho salmon smolt abundance and estimates of apparent 2015-2016 coho salmon overwinter survival using out-migrant trapping and PIT tag antenna array data collected by the Smith River Alliance and the California Department of Fish and Wildlife (CDFW) in the Mill Creek Lifecycle Monitoring Station, Smith River basin, California. We also include abundance estimates for steelhead and coastal cutthroat trout smolts and pre-smolts. Based on current project funding, the Smith River Alliance will continue to operate the Mill Creek out-migrant trap in 2017. A proposal funding all components of the Mill Creek Lifecycle Monitoring Station, including operation of the out-migrant trap, PIT tag antennas, spawning surveys, fall marking of juvenile coho salmon with PIT tags and genetic mark-recapture through the spring of 2020 is currently under consideration.

Declines in coho salmon abundance across California have resulted in their listing under both the California and federal Endangered Species Acts (Federal Register 1997, CDFG 2002). State and federal restoration plans have called for the creation of long-term assessment and monitoring programs to both assist in and gauge the effectiveness of coho salmon recovery efforts (CDFG 2004, NMFS 2014). Creating such programs is especially important for coho salmon in basins like the Smith River, where until relatively recently, very little comprehensive monitoring designed to quantify specific population recovery metrics has taken place.

The first steps toward a comprehensive long-term monitoring program for Smith River coho salmon began in 2011 when California Department of Fish and Wildlife (CDFW) and the Smith River Alliance (SRA) implemented a sampling program driven by goals outlined by Adams et al. (2011) to assess the population abundance and geographical distribution of salmonids throughout their California ranges. In this randomized reach-based sampling program consistent with the region-wide California Coastal Salmonid Monitoring Plan (CMP), spawning ground surveys are utilized to track trends in adult coho salmon redd abundance while juvenile snorkel surveys are utilized to assess trends in their spatial structure. These adult spawning and juvenile snorkel surveys conducted across the Smith basin during the past five years by CDFW/SRA, confirm the importance of Mill Creek to the Smith River coho salmon core population (Garwood and Larson 2014, Garwood et al. 2014, Walkley and Garwood 2015).

Mill Creek is the subject of the longest continuous fisheries monitoring in the Smith Basin (McLeod and Howard 2010, Larson 2013). Out-migrant pipe traps located on its two major tributaries, the East Fork and West Branch Mill Creek, began operation in 1994 and continued through 2012 when the Mill Creek Monitoring Group dissolved. CDFW temporarily took over the trapping effort from 2013 through 2015 to maintain data collection while alternative management and funding sources were pursued to adapt the program to fit specific goals of a CMP Lifecycle monitoring station (LCM) defined in Adams et al. (2011). The Smith River Alliance applied for and received a FRGP grant to conduct smolt out-migrant trapping in 2016 and 2017.

The goals of this out-migrant trapping project are to ensure that the CMP's goal of a lifecycle monitoring station is fully implemented. Lifecycle Monitoring (LCM) stations – as described the California Coastal Salmonid Monitoring Program (Adams et al. 2011) – are intended to estimate ocean and freshwater survival to better assess salmonid recovery. Each LCM station consists of 3 primary components: 1) an adult counting station, 2) spawning surveys above the counting station, and 3) out-migrant juvenile trapping. Components 1 and 2 of the Mill Creek LCM station are currently in place through other partner projects. An adult counting weir does not exist in the Mill Creek basin and is not feasible due to the large, flashy nature of the drainage and its management under the State and National Parks. Instead of installing a weir, Passive Integrated Transponder (PIT) antenna arrays situated at the mouths of East Fork and West Branch Mill Creek and in the lower main stem Mill Creek intercept returning PIT tagged adult coho salmon. Reach-based spawning surveys, which include the use of portable PIT tag scanners for detection of

returning tagged adults, occur throughout Mill Creek in all designated coho salmon spawning areas. Together these projects will be used to estimate both the number of returning adults and their distribution throughout the system though the success of these methods have yet to be assessed since the winter of 2014-2015 is the first year that returning adult coho salmon will have having a group marked with PIT tags. Out-migrant trapping provides a means to estimate the abundance of outmigrating coho salmon smolts, a capture point essential for apparent overwinter survival estimation, and also is a means of tagging smolts to estimate ocean survival. Additionally, Humboldt State University and CDFW are assessing the utility of genetic mark-recapture techniques in Mill Creek by estimating the number of returning adults from estimated parentage rates of genotyped adult carcasses with genotypes from a sample of their smolt offspring similar to (Rawding et al. (2014).

Materials and Methods

Out-migrant Trap Site Description

The Mill Creek out-migrant trapping site is located 2.4 stream kilometers upstream from its confluence with the Smith River, and approximately 0.65 stream kilometers downstream of the Howland Hill Road bridge (Figure 1 and Figure 2) in Redwood National and State Parks. The rotary screw trap was placed at the head of a 35 meter long pool immediately upstream of a large corner pool. This site offers both bankside refugia during high flows, as well as sufficient depth and focused current to allow the rotary screw trap to operate during the latter part of the trapping season. Nearby old growth redwoods and alders provide ample shade for trapping and fish handling activities.

Out-migrant Trap Operation

The out-migrant trapping conducted in 2016 closely followed the methodology implemented CDFW during the 2014 and 2015 Mill Creek trapping seasons (Walkley et al. 2015) and followed a strategy and methods outlined in the California Salmonid Monitoring Plan (Adams et al. 2011). This trapping methodology incorporated methods used in previous monitoring efforts to estimate smolt populations in Mill Creek and Freshwater Creek (McLeod and Howard 2010, Ricker and Anderson 2011) and methods used in Freshwater Creek by Ricker and Anderson (2011) to estimate overwinter survival. The rotary screw trap (RST) deployed in Mill Creek was built by EG Solutions and consists of a flow-driven 5 foot cone and 18 foot pontoons. A built-in covered live well with a cone-driven debris removal drum is mounted posterior to the cone. The trap was anchored to large riparian trees with a cable and pulley system so in-stream adjustments could be made to optimize trap revolutions. The RST operated over a range of flows as measured at the USGS Jed Smith stream gage. In anticipation of steeply rising water levels or increased debris loads, the trap cone was removed from the water and/or the entire trap was moved to the margin of the stream. Fishing at the upper end of the flow range only occurred as flows declined. The RST was left fishing during smaller flow increases; however it was closely monitored. Weir panels were installed in front of the trap pontoons to focus water flow into the trap cone as water flow decreased toward the latter half of the season. Weir panels were angled and completely covered in plastic pond liner with all seams and holes covered to avoid fish impingement. However, we attempted to balance daily trap capture efficiency while minimizing migration obstacles for not-target organisms such as Pacific lamprey and adult steelhead. The screw trap was checked and cleaned once daily in the morning with multiple cleanings occurring throughout the day during peak migration periods or as debris loads required. Fish were removed with 3/16"(or finer) cloth dip nets and placed in 5-gallon buckets containing fresh creek water or in fine mesh live-cars anchored in the channel margin immediately adjacent to the shaded fish processing station.

Figure 1. Map of the Smith River Basin, Del Norte County (California) and Curry County (Oregon) and the Mill Creek LCM station. Stream lines indicate potential anadromous salmonid stream habitat based on Garwood and Larson (2014).

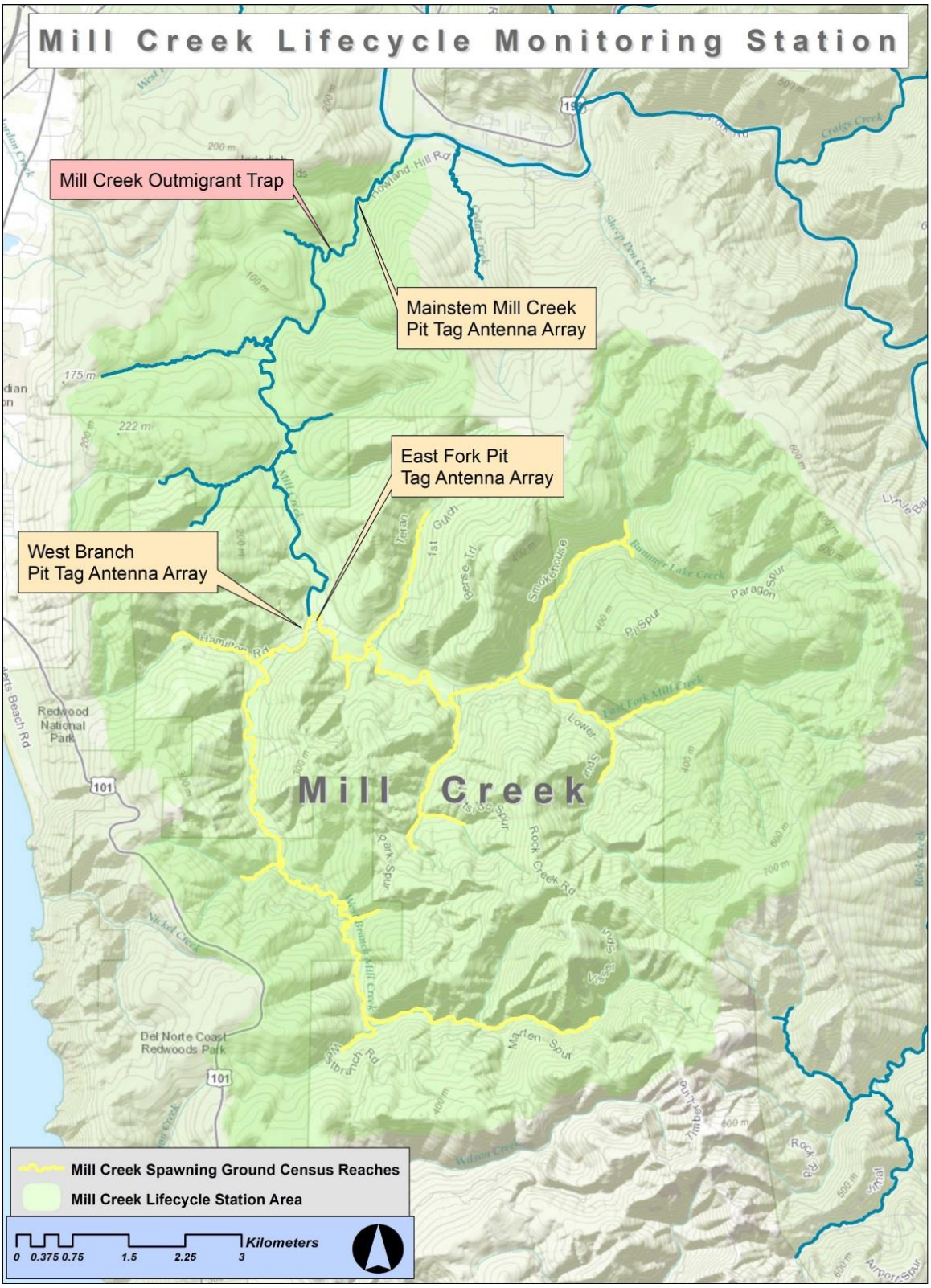

Figure 2. Mill Creek Lifecycle Monitoring Station out-migrant trapping and PIT tag antenna array locations, Smith River basin, CA.

All captured salmonids were identified to species and classified by their developmental stage as: young-of-the-year (YOY), parr, pre-smolt, smolt, or adult. Because of the difficulty in distinguishing between juvenile coastal cutthroat trout and steelhead trout, even by trained and experienced samplers, all trout < 100 mm were identified as trout spp. and were classified as YOY or as parr. Trout > 100mm were identified as cutthroat trout or steelhead and assigned a life stage. YOY were generally small in size and had distinct parr marks. Parr possessed distinct parr marks. Samplers made a distinction between steelhead and cutthroat trout pre-smolt and smolts. Those cutthroat trout and steelhead whose body was silver and had completely obscured parr marks, darkening fin edges and deciduous scales were classified as smolts while individuals displaying some but not all of these characteristics were classified as pre-smolts. Steelhead and cutthroat trout > 150mm FL and not displaying parr marks or showing signs of smolting were classified as adults. Following Mcleod and Howard (2010), all coho showing signs of smolting were classified as smolts.

All Chinook salmon were classified as YOY unless exceptionally large individuals (yearlings) were captured. The first 20 individuals of each species/developmental stage were measured to the nearest mm (FL). All parr, pre-smolts and smolts were scanned for PIT tags and were checked for fin clips. Those with fin clips and those not included in the trapping efficiency and smolt abundance estimation were released 1-3 habitat units downstream of the trap. Coho salmon PIT tagged by DFW during the fall of 2015 were measured and weighed to the nearest 0.1g and—if not fin clipped—were marked with the designated weekly batch clip and released upstream of the trap.

Lamprey were identified to species and classified to life stage, measured and released downstream of the trap. Nonanadromous fish and amphibians were identified to species. A representative subsample was measured to the nearest mm and all fish were released at multiple locations downstream of the trap to avoid predator habituation.

Out-migrant Smolt Abundance Estimates

A single trap mark-recapture strategy was used to estimate trapping efficiency and coho salmon smolt abundance following McLeod and Howard 2010 and Ricker and Anderson (2011). Each day, a representative sample of previously unmarked coho salmon smolts were tagged with individually numbered PIT tags (Prentice 1990, Prentice et al. 1994) and received a fin clip. The fin clip from each individual tagged with a PIT tag was preserved and deposited into the DFW's North Coast Scale and Tissue Archive. Four different batch fin clips were used over the course of trapping: upper horizontal caudal clip (UHC), lower horizontal caudal clip (LHC), upper vertical caudal clip (HVC) and lower vertical caudal clip (LVC). A single clip was applied for roughly seven days before switching to another one, allowing a gap of 3 weeks between each tag group. The goal was to deploy 1500 PIT tags across the Coho salmon outmigration season. These individually tagged fish were used to track movement and distribution and will be used to estimate marine survival and adult abundance when recaptured as adults on the PIT tag antenna arrays and on spawning surveys by partner projects. During periods of high smolt abundance, additional coho smolts were marked only with fin clips. Following tagging and/or marking, fish were held in flow-through live cars to check for handling/marking mortality before being released upstream of the trap. Releases occurred at rotating sites between 1 and 3 pool/riffle complexes upstream of the trap to minimize predator habituation. The same marking methodology was followed for steelhead and cutthroat trout pre-smolts and smolts; however, none were tagged with PIT tags. Mark-recapture of fin clips was broken into time intervals and bounded estimates of abundance were calculated for Coho salmon, steelhead and cutthroat trout using DARR 2.0.2 (Bjorkstedt 2005 and Bjorkstedt 2010) in program R (R development Core Team 2013). For abundance estimates, smolts and pre-smolts were lumped together and the single trap experiment with no *a priori* pooling of strata was used.

Estimation of Apparent Overwinter Survival

Program MARK (White and Burnham 1999) was used to perform a three-occasion Cormack-Jolly-Seber (CJS) analysis (Cormack 1964, Jolly 1965, Seber 1965) to estimate the 'apparent' survival probabilities for marked juvenile Coho salmon in the three subbasins of Mill Creek (i.e. East Fork, West Branch, and mainstem Mill Creek). CJS models allow for imperfect detection while using common capture methods (e.g. rotary screw trap, stationary PIT tag antenna, etc.) by accounting for detection probability (Cooch and White 2011). When using CJS models, the survival estimates are called 'apparent' due to the model's inability to distinguish between mortality and undetected permanent emigration of marked individuals. The first occasion used in the CJS model was the initial PIT tagging (1). The second and third encounters occurred simultaneously throughout the following spring and are represented in the analysis as captures at the rotary screw trap (2) and the main stem Mill Creek PIT tag antennas (3), respectively.

To satisfy the first occasion of the CJS model, fish tagging was performed by CDFW field crews in fall 2014 and 2015, when rearing fish were still associated with their summer rearing habitat. A stratified selection of pool habitats was sampled throughout the East Fork, West Branch and mainstem Mill Creek using beach seines. All sampled habitats were above the out-migrant trapping site. Sampled portions of the West Branch and the East Fork extended from their mouths upstream and included much of main channel habitat utilized by rearing Coho salmon. The coho salmon seined from pools were measured, weighed and implanted with PIT tags in each reach in October of 2014 and 2015. Juvenile coho salmon were marked by surgical incision following the tagging methodology of Prentice et al. (1990). To minimize effects of added tag-weight to juvenile coho salmon, size-at-tagging restrictions recommended in Peterson et al. (1994) were followed such that PIT tags of 12.0 mm long × 2.12 mm diameter weighing 0.1 g were used for fish ≥ 65 mm during fall of 2014. In fall of 2015, in compliance with a change in minimum size at tagging restrictions, 12 mm PIT tags were used for fish ≥ 70 mm.

The secondary occasion in the CJS model was collected from recaptures of the fall-tagged fish during daily operation of the rotary screw trap. The third and final occasion in the model was fulfilled through continuous operation of a PIT-tag monitoring antenna array located downstream of the out-migrant trapping station (Figure 2). This particular array features two channel-spanning pass-over (i.e. 'flat plate' style) antennas stapled to the substrate. Pass-through (i.e. vertical) antennas are at risk of damage from flood events in streams which routinely experience high annual precipitation totals like Smith River tributaries. As a tradeoff, our pass-over design sacrifices capture efficiency but allows for continuous operation during the wettest months which is essential for detecting early redistribution and emigration.

In addition to the mainstem PIT tag antenna site, two pairs of antennas operated at the mouths of East Fork and West Branch Mill Creek were used to assess year-round movement patterns of juvenile coho salmon. Likewise, CDFG operated two antennas in tributaries to the lower Smith River from which we obtained capture records of coho salmon tagged in Mill Creek. These additional antennas greatly helped strengthen our understanding of coho salmon winter redistribution and early emigration (i.e. fall or winter out-migration that precedes screw trap installment).

Database and Data Storage

Out-migrant trapping data was collected using field computers (PDA's) operating the DFW Coastal Monitoring Program Aquatic Survey Program database (current version: 0.9.7.) (Burch et al., 2014). Data fields in all PDA forms were fixed within specific ranges to minimize data entry error. Standard QAQC queries were run each day after PDA's were downloaded to correct data errors directly after surveys were completed. Databases were backed up once a week.

2016 Mill Creek LCM Out-migrant Trapping Results and Discussion

Out-migrant Trapping Effort and Overall Catch

The RST was installed in lower Mill Creek on the afternoon of March 16, 2016 and remained in operation until it was removed on the afternoon of June 18, 2016 (Figure 3). Trapping continued almost continually during this 94 day period with the exception of one high flow event that prompted a loss of 2 trapping days. The RST was moved to the stream margin at 11AM March 21 and re-deployed at 11AM on March 23. During this period flows at the USGS Jed Smith gaging station peaked around 18,800 CFS (U.S. Geological Survey 2012). Frequent adjustments allowed the trap to keep fishing during smaller storm events. As in 2015, trap cone rotations per minute (RPM) were higher during the first half of the trapping season, but decreased as seasonal flow decreased (Figure 3). Three sharply downstream angled weir panels were installed upstream of the trap on the afternoon of April 3 with a goal of focusing juvenile migration toward the cone of the trap and away from a high-water secondary channel on river left of the trap. These panels were removed on April 13 in anticipation of a storm event and re-deployed on April 19. Additional panels were added on river right of the trap on April 17 to focus flow into the trap cone.

Total counts of unique individuals (excluding recaptured marked fish) of each species and stage captured by the RST in 2016 can be found in Table 1. Counts from the 2015 trapping season are also included for comparison (Walkley et al. 2015). Four species of salmonids were captured. Chinook Salmon YOY were by far the most abundant fish captured in the RST followed by unidentified trout YOY in 2016. Coho salmon smolts were the next most abundant salmonid life stage captured. Notably, although they occurred in lower numbers than either Chinook salmon or trout YOY, coho salmon YOY were captured in the RST. While it is possible that these YOY emerged from redds in the mainstem of Mill Creek, no coho salmon have been

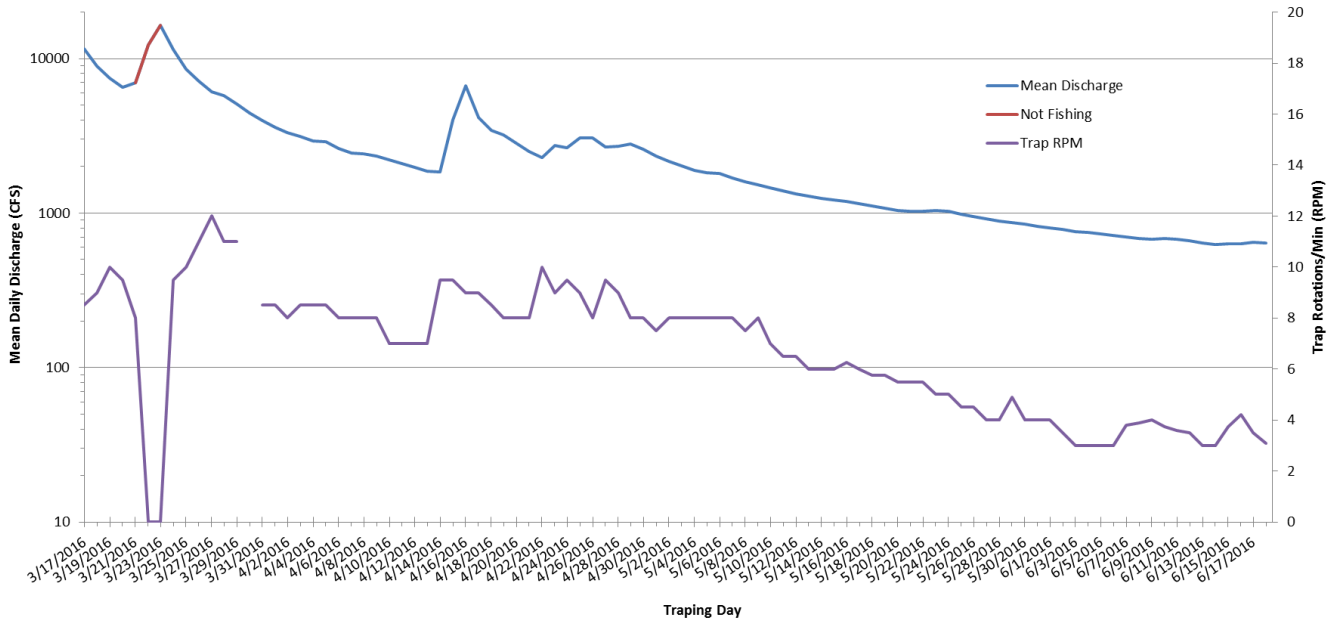

Figure 3. Daily Mill Creek rotary screw trap effort measured by trap cone rotations per minute (RPM) each morning from March 17, 2016 through June 18, 2016 and average daily discharge at the Jed Smith USGS gage station. Gaps in RPM indicate missing data while red lines in discharge indicate periods over which the trap was not fishing.

observed building redds in the mainstem of Mill Creek over the five years of CMP spawning surveys (Garwood and Larson 2014, Garwood et al. 2014, Walkley and Garwood, 2015, Walkley and Garwood 2017). Thus, these individuals may be evidence of an early emigration life history strategy undertaken by coho salmon YOY originating from West Branch and East Fork Mill Creek. Similar numbers of both steelhead and coastal cutthroat trout smolts were captured in 2016. However, more steelhead parr and pre-smolts were captured than either coastal cutthroat trout parr or pre-smolts. Nonsalmonid captures in the RST included 14 adult Pacific lamprey, which was similar to the number captured in 2015. We strived to avoid the incidental capture of adult Pacific lamprey as well as adult steelhead by maintaining small migration routes around the RST. Klamath smallscale suckers comprised the bulk of the non-salmonid catch with prickly sculpin and Coast Range sculpin also captured. Very few amphibians were captured.

Out-migrant Smolt Abundance Estimates

Mark-recapture of fin clipped smolts and pre-smolts was used to estimate the abundance of out-migrating coho salmon, steelhead and coastal cutthroat trout over the course of the trapping season. A total of 1,178 coho salmon smolts were tagged with PIT tags. These tagged coho salmon were also marked with caudal fin clips. Non PIT-tagged coho salmon were also marked with fin clips. Fourteen distinct caudal fin clip strata were released over the course of trapping (Table 2). 1,635 coho salmon smolts were clipped and released upstream of the RST and 521 individuals were recaptured. Using DARR, the 2016 estimated spring population of Mill Creek emigrating coho salmon smolts was 7,541 (SE=439.64) smolts (Figure 4). By contrast, we estimated that 8,231 (SE=307.97) smolts emigrated past the RST site in 2015 (Walkley et al. 2015). Coho salmon outmigration in 2016 appeared to occur at a more even rate than in 2015 (Walkley et al. 2015). In 2015 the highest numbers of coho salmon in lower Mill Creek occurred during late April through early May. With the exception of a two week period during the weeks of April 10th and April 17th, the estimated number of coho smolts passing the RST in 2016 remained elevated from late March through late May. Estimated probability of capture (trapping efficiency) for out-migrating coho salmon averaged 30% (min=12%, max=85%) across the entire trapping season. Trapping efficiency increased after the installation of the weirs panels on April 19 but decreased slightly thereafter until mean daily discharge measured at the USGS Jed Smith gauge dropped below 1000cfs.

A total of 404 steelhead were clipped and released upstream of the RST and 105 were recaptured. An estimated 2,077 (SE= 468.78) steelhead smolts and pre-smolts emigrated from Mill Creek during the spring of 2016 (Figure 5). Estimated trapping efficiency for out-migrating steelhead averaged 27% (min=17%, max=55%) across the entire trapping season. The estimate of emigrating steelhead smolts and pre-smolts is likely biased low. It is evident from the mark recapture data that steelhead outmigration occurred primarily during the first half of the trapping season (Table 2). High numbers of smolts and pre-smolts were captured during the first trapping stratum, suggesting only a portion of the out-migrating population was sampled. Similar patterns were observed in the 2015 steelhead smolt migration by Walkley et al. (2015).

A total of 246 cutthroat trout were clipped and released upstream of the RST and 33 were recaptured. An estimated 2,447 (SE= 584.20) cutthroat smolts and pre-smolts emigrated from Mill Creek (Figure 6). Estimated trapping efficiency for out-migrating cutthroat trout averaged 13% (min=9%, max=16%) across the entire trapping season. By contrast, estimated trapping efficiency for coastal cutthroat trout during the 2015 trapping season averaged 26% (min=12%, max=63%) across the entire trapping season and an estimated 4,385 (SE= 540.27) cutthroat smolts and pre-smolts emigrated from Mill Creek (Walkley et al. 2015).

Table 1. Total numbers of individuals captured in the Mill Creek out-migrant trap from March 16 through June 15, 2015 and March 16 through June 18, 2016. Totals exclude recaptured fin clipped fish used to estimate smolt abundance.

Common Name (Scientific Name)	Stage	2015 Captures[a,b]	2016 Captures[a]
Chinook Salmon (*Oncorhynchus tshawytscha)*	YOY	47400	114797
	smolt	-	4
Coho Salmon (*Oncorhynchus kisutch*)	YOY	383	1158
	smolt	3535	2202
Steelhead (*Oncorhynchus mykiss*)	parr	2014	1337
	pre-smolt	537	214
	smolt	24	201
	adult	1	-
Coastal Cutthroat Trout (*Oncorhynchus clarki clarki)*	parr	591	454
	pre-smolt	765	95
	smolt	86	209
	adult	28	23
Unidentified Trout (*Oncorhynchus sp.*)	YOY	1139	2367
	parr	2239	974
Coast Range Sculpin (*Cottus aleuticus*)	resident	142	92
Prickly Sculpin (*Cottus asper*)	resident	127	198
Unidentified Sculpin (*Cottus sp.*)	resident	90	77
Three-spined Stickleback (*Gasterosteus aculeatus*)	resident	35	30
Klamath Smallscale Sucker (*Catostomus rimiculus*)	resident	1299	1432
Pacific Lamprey (*Lampetra tridentata*)	adult	13	14
Lamprey genus (*Lampetra sp.*)	ammocoete	11	8
Coastal Giant Salamander (*Dicamptodon tenebrosus)*	larvae	8	3
Foothill Yellow-legged Frog (*Rana boylii)*	larvae	1	-
	adult	-	1

[a] individuals captured exclude recaptured individuals marked with fin clips and include mortalities.
[b] 2015 RST captures from Walkley et al. (2015)

Table 2. Mill Creek out-migrant trap marking strata, number of unmarked individuals captured (C) and number of marked (M) coho salmon, steelhead and cutthroat trout released upstream of the Mill Creek out-migrant trap from March 16 through June 18, 2016.

Marking Stratum	Start Date	End Date	Clip	Coho Salmon		Steelhead		Cutthroat	
				C[1]	M[2]	C	M	C	M
1	3/17/2016	3/19/2016	UHC	26	24	30	29	13	13
2	3/20/2016	3/26/2016	LHC	24	24	64	64	9	6
3	3/27/2016	4/2/2016	UVC	87	87	95	94	28	28
4	4/3/2016	4/9/2016	LVC	81	79	65	63	15	12
5	4/10/2016	4/16/2016	UHC	49	49	34	33	24	18
6	4/17/2016	4/23/2016	LHC	90	88	42	40	39	35
7	4/24/2016	4/30/2016	UVC	189	164	32	32	27	19
8	5/1/2016	5/7/2016	LVC	382	233	27	25	31	27
9	5/8/2016	5/14/2016	UHC	272	180	15	14	39	38
10	5/15/2016	5/21/2016	LHC	492	298	7	7	28	28
11	5/22/2016	5/28/2016	UVC	216	176	0	0	9	9
12	5/29/2016	6/4/2016	LVC	160	123	0	0	10	7
13	6/5/2016	6/11/2016	UHC	91	81	3	2	6	2
14	6/12/2016	6/18/2016	LHC	32	29	1	1	4	4

[1]Total number of captured unmarked individuals includes mortalities and first captures of Fall-tagged coho salmon.

[2]Total marked individuals released upstream of RST during each marking stratum.

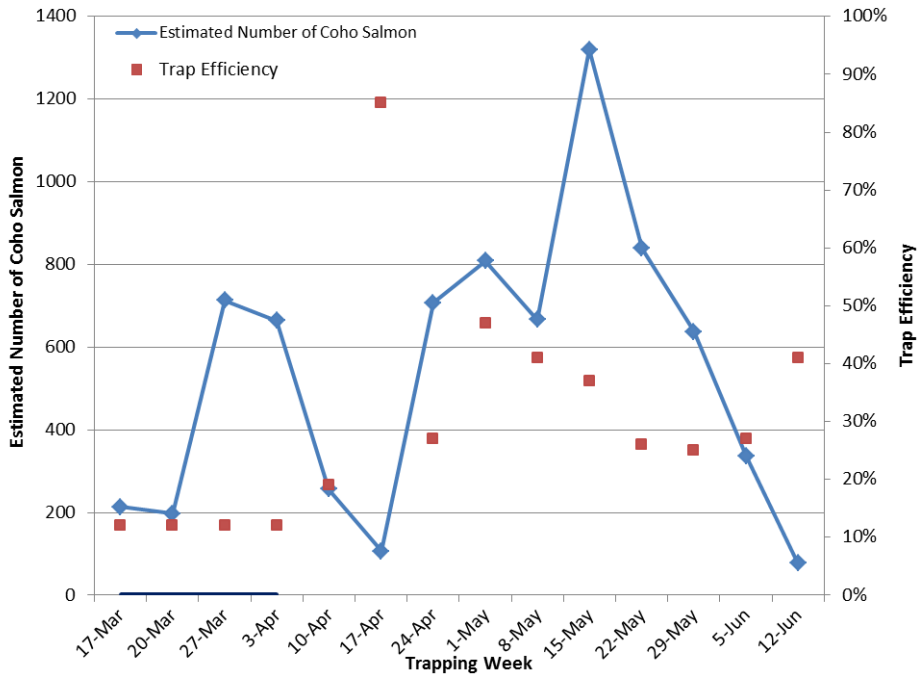

Figure 4. DARR estimates of coho salmon smolt abundance for each marking strata at the Mill Creek out-migrant trap between March 16 and June 18, 2016, Smith River basin, CA. Dates represent the start of each trapping week and black bars between dates indicate pooled marking strata.

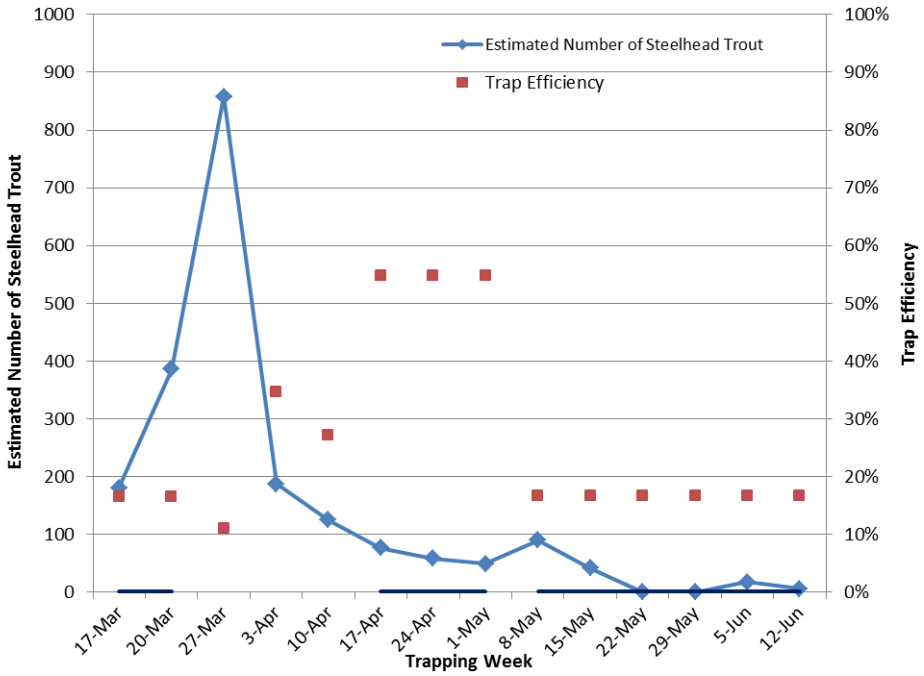

Figure 5. DARR estimates of combined steelhead smolt and pre-smolt abundance for each marking strata at the Mill Creek out-migrant trap between March 16 and June 18, 2016, Smith River basin, CA. Dates represent the start of each trapping week and black bars between dates indicate pooled marking strata.

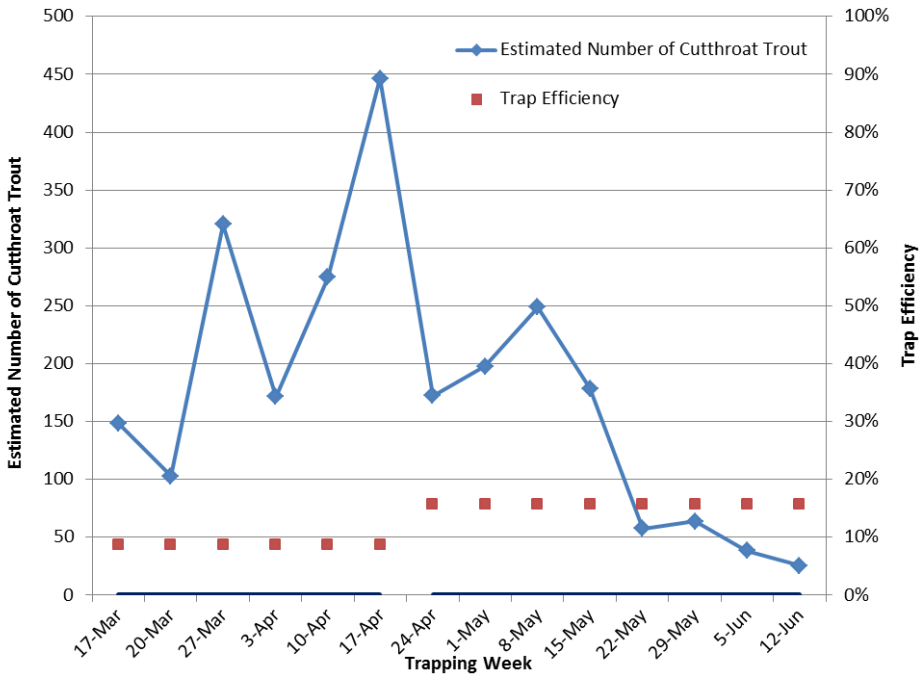

Figure 6. DARR estimates of combined coastal cutthroat smolt and pre-smolt abundance for each marking strata at the Mill Creek out-migrant trap between March 16 and June 18, 2016, Smith River basin, CA. Dates represent the start of each trapping week and black bars between dates indicate pooled marking strata.

Estimation of 'Apparent' Overwinter Survival

Cormack-Jolly-Seber (CJS) mark-recapture models allow for the estimation of 'apparent' survival of a marked population while accounting for imperfect detection. Here, survival is referred to as 'apparent' instead of 'true survival' because CJS models cannot separate estimates of mortality from permanent emigration from the study area. Since our marked population in Mill Creek was 'open' (i.e. coho salmon can emigrate permanently from the study area) our estimates are 'apparent' overwinter survival, which hereafter will be referred to as "overwinter survival" or just "survival" for ease of presentation.

Overwinter survival of coho salmon during 2015-16 in all of Mill Creek was estimated to be 13.1 percent with a 95% confidence interval of between 7.9% and 20.8% (Table 3). A separated subbasin model estimated overwinter survival for West Branch Mill Creek at 15.4% (95% C.I. = 8.5% - 26.4%) and East Fork Mill Creek at 10.8% (95% C.I. = 6.2% - 18.1%). CDFW was unable to tag a sample of coho salmon in the mainstem of Mill Creek during the fall of 2015 due to funding constraints and thus, we are unable to provide a 2015-2016 overwinter survival estimate for the mainstem Mill Creek subbasin. In 2014-2015 the estimated overwinter survival of coho salmon in all of Mill Creek was 18.1% (SE = 0.026) with a 95% confidence interval of 13.6% to 23.7% (Walkley et al., 2015). A separate subbasin model estimated the 2014-2015 overwinter survival of tagged coho salmon in the main stem, West Branch and East Fork Mill Creek subbasins to be 6.4%, 18.3% and 21.3%, respectively. Survival estimates from both 2014-2015 and 2015-2016 in Mill Creek are lower than those estimated by other studies in nearby basins such as Prairie Creek and Freshwater Creek (Rebenack et al. 2015; Sparkman et al. 2015; Ricker and Anderson 2011).

The 2015-2016 raw count capture summaries of PIT tagged coho salmon tagged in the fall of 2015 are provided in Table 3 while 2014-2015 summaries can be found in Walkley et al. (2015). Examining these data can be useful in determining if fish are migrating within or out of the Mill Creek subbasin. When

analyzing counts from stationary PIT tag antennas, it should be pointed out that the data do not account for missed fish (i.e. detection of passing animals is imperfect). Therefore the counts should not be viewed as entirely proportional to the population. Instead, only large and consistent differences in survival and movement among subbasins should be evaluated. For example, in both years the total number of early coho salmon movements into West Branch Mill Creek were more than quadruple those entering East Fork Mill Creek. This could suggest a greater tendency for coho salmon in the East Fork to redistribute during the overwinter rearing period.

Life histories of coho salmon in coastal Northern California are generally understood to include freshwater occupancy for one or two years before migrating seaward the following spring. Recent studies in the Freshwater Creek basin (Rebenack et al. 2015; Ricker and Anderson 2011) indicate that a similar life history strategy is expressed by some juvenile coho salmon that could be described as a fall re-distribution or a fall outmigration. This alternative life-history strategy is exhibited by some coho salmon in Mill Creek as is evident by captures of 23 and 100 early emigrants on the main stem Mill Creek antenna array and in the lower Smith River during 2014-15 and 2015-16 respectively (Parish and Garwood, 2015, Walkley et al., 2015, Parish and Garwood 2016 and Table 3). In 2014-2015 Parish and Garwood (2015) found non-natal coho salmon over summering and over wintering in the lower Smith River and its estuary. While minnow trapping during January and February of 2015, they recaptured four coho salmon juveniles in the lower mainstem Smith River and one of its tributaries, Morrison Creek, which had been PIT tagged as part of the 2014 Mill Creek Fall tagging effort. Inspired by their findings from 2014-2015, CDFW obtained permission to install two PIT-tag antenna arrays in Morrison Creek and Tryon Creek—another lower Smith River tributary—to monitor non-natal coho salmon in the lower Smith River. In 2015-16 these two estuary antenna arrays captured 90 individual coho salmon which had been PIT tagged as part of the 2015 Mill Creek Fall tagging effort preceding the out-migrant trap installment date (Parish and Garwood 2016, Table 3). These detections show that a significant proportion of juvenile coho salmon migrated out of Mill Creek during late fall and winter months. While our survival estimates suggest juvenile coho salmon in Mill Creek likely experienced low overwinter survival coupled with high potential for early emigration, it is premature to expect this pattern annually and further investigation is needed.

Table 3. Summary of raw detections during CDFW mark-recapture efforts for coho salmon in Mill Creek from tagging in fall 2015 through June 2016. Coho detection values represent basin-specific counts of individual coho salmon detected throughout monitoring seasons. Coho salmon movement values represent counts of individuals detected redistributing among subbasins before spring migration. 'Apparent' overwinter survival estimates derived using Program MARK (White and Burnham1999) and represents the probability an individual did *not* emigrate early and survived through winter.

2015-16 Mill Creek Sub-basins (tagging locations):	**WBM[a]**	**EFM[b]**	**Total[c]**
Individually Tagged Coho Salmon:	406	415	821
Coho Detections:			
Detected early emigrants[a], Nov 1-Mar 15	41	59	100
Mainstem antennas, Mar 15-Jun 15	6	13	19
Screw trap recaptures, Mar 15-Jun 15	24	19	43
Detected overwinter survivors, Nov 1-Mar 15	28	25	53
Early Coho Movements:			
To East Fork	5	0	5
To West Branch	0	21	21
To Mainstem Mill Creek	10	7	17
To Smith River	6	6	12
To Estuary	36	54	90
Estimated 'Apparent' Overwinter Survival	**15.4%**	**10.8%**	**13.1%**
Upper 95% Confidence Interval	*26.4%*	*18.1%*	*20.8%*
Lower 95% Confidence Interval	*8.5%*	*6.2%*	*7.9%*

[a] Includes individuals detected on antennas in either mainstem Mill Creek or the Smith River estuary
[b] fish tagged in West Branch Mill Creek subbasin
[c] fish tagged in East Fork Mill Creek subbasin
[d] fish tagged in all of Mill Creek

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