2020 Coyote Creek Watershed Fisheries Monitoring

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Reports included:

2020 Juvenile *Oncorhynchus mykiss* Rearing Monitoring in Upper Penitencia Creek

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Coyote Creek 2019 – 2020 Adult Salmonid Migration Monitoring Using the Vaki Riverwatcher Passive Monitoring System at the Coyote Percolation Dam Fish Ladder

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Executive Summary

To better understand juvenile steelhead (*Oncorhynchus mykiss, O. mykiss*) abundance and distribution, Valley Water performed index reach monitoring for juvenile *O. mykiss* on Upper Penitencia Creek. The goal of the monitoring was to document the abundance, distribution, and densities of all fish in Upper Penitencia Creek as well as to collect *O. mykiss* genetic information and continue tagging fish for a tracking study implemented in 2019 using Passive Integrated Transponder (PIT) tags. Monitoring was conducted under the National Marine Fisheries Service Section 10(a)1(A) Recovery Permit # 16417-2R and California Department of Fish and Wildlife Scientific Collecting Permit # 11325.

On August 4 and 5, 2020, monitoring was conducted at 5 monitoring stations on Upper Penitencia Creek. Multi-pass depletion backpack electrofishing was conducted at each station. Appropriately sized *O. mykiss* received PIT tags to study their movement within the Coyote Creek Watershed. Juvenile *O. mykiss* were present in Upper Penitencia Creek with 15 (0.05 *O. mykiss*/m) individuals captured. No non-native fish were observed or collected on Upper Penitencia Creek during sampling.

This juvenile rearing monitoring is part of a continuing effort to better understand *O. mykiss* distribution and abundance in the Coyote Creek Watershed. This is the second year of surveys on Upper Penitencia Creek, but only three of the five stations sampled this year were sampled in 2019, due to dry backs at the most downstream station. Densities were lower in 2020 (0.05 *O.mykiss*/m) than in 2019 (0.39 *O. mykis*s/m). It is difficult to assess any trends at this time, but a better understanding of *O. mykiss* populations in Upper Penitencia Creek will develop as more data becomes available.

Contents

Tables

Figures

1. Introduction

The Coyote Creek Watershed is the largest watershed in Santa Clara County, encompassing over 829 square kilometers. The eastern and southern portions of the watershed drain most of the western face of the Diablo Mountain Range where the creek originates at elevations up to 1,110 meters. These upper watershed areas remain undeveloped with little anthropogenic disturbance. The northern and western portions of the watershed are comprised of the Santa Clara County valley floor. Portions of the valley floor are extensively urbanized with patches of undeveloped parks and open agricultural lands. Coyote Creek has 29 tributaries and flows northwest through the valley, approximately 68 kilometers from the headwaters, where it enters the southern extent of the San Francisco Bay. The Coyote Creek Watershed supports the federally threatened Central California Coast steelhead (*Oncorhynchus mykiss; O. mykiss* for the remainder of this document) distinct population segment. Two systems in the Coyote Creek Watershed are defined as critical habitat for *O. mykiss*: Coyote Creek and Upper Penitencia Creek. Coyote Creek critical habitat extends from the creek's confluence with the San Francisco Bay to the base of the Leroy Anderson Dam. Upper Penitencia Creek critical habitat extends from the creek's confluence with Coyote Creek to the base of the dam at Cherry Flat Reservoir. To better understand *O. mykiss* abundance and distribution within these systems, Valley Water performs index reach monitoring for juvenile *O. mykiss* on Coyote and Upper Penitencia Creek. Index reach monitoring for juvenile *O. mykiss* was not conducted on Coyote Creek this year due to the order by the Federal Energy Regulatory Commission (FERC) to drain Anderson Reservoir, which led Valley Water to conduct a fish rescue and relocation on Coyote Creek in place of the yearly monitoring. The goal of the monitoring was to document the abundance, distribution, and densities of all fish in Upper Penitencia Creek, as well as to collect *O. mykiss* genetic information and implement a tracking study using Passive Integrated Transponder (PIT) tags.

2. Methods

2.1 Station Selection

A total of 5 stations were sampled on Upper Penitencia Creek. Stations were resampled if feasible based on last year's sampling stations and two additional areas of interest were targeted. Site selection was limited to locations of Valley Water ownership or easement, or to locations owned by other government agencies.

The area of study for Upper Penitencia Creek was defined as the section between the Piedmont Road overcrossing to the upper extent of the City of San Jose's property upstream of Alum Rock Park. This area was selected as it had the highest likelihood of being wetted throughout the sampling period. Four sampling stations were randomly selected in 2019, however the most downstream station dried back this year and could not be resampled. Stations 2 through 4 were resampled this year and two more stations were added in the wetted portion Upper Penitencia Creek to try to gain a better understanding of *O. mykiss* densities in the system and to help inform the fish relocation
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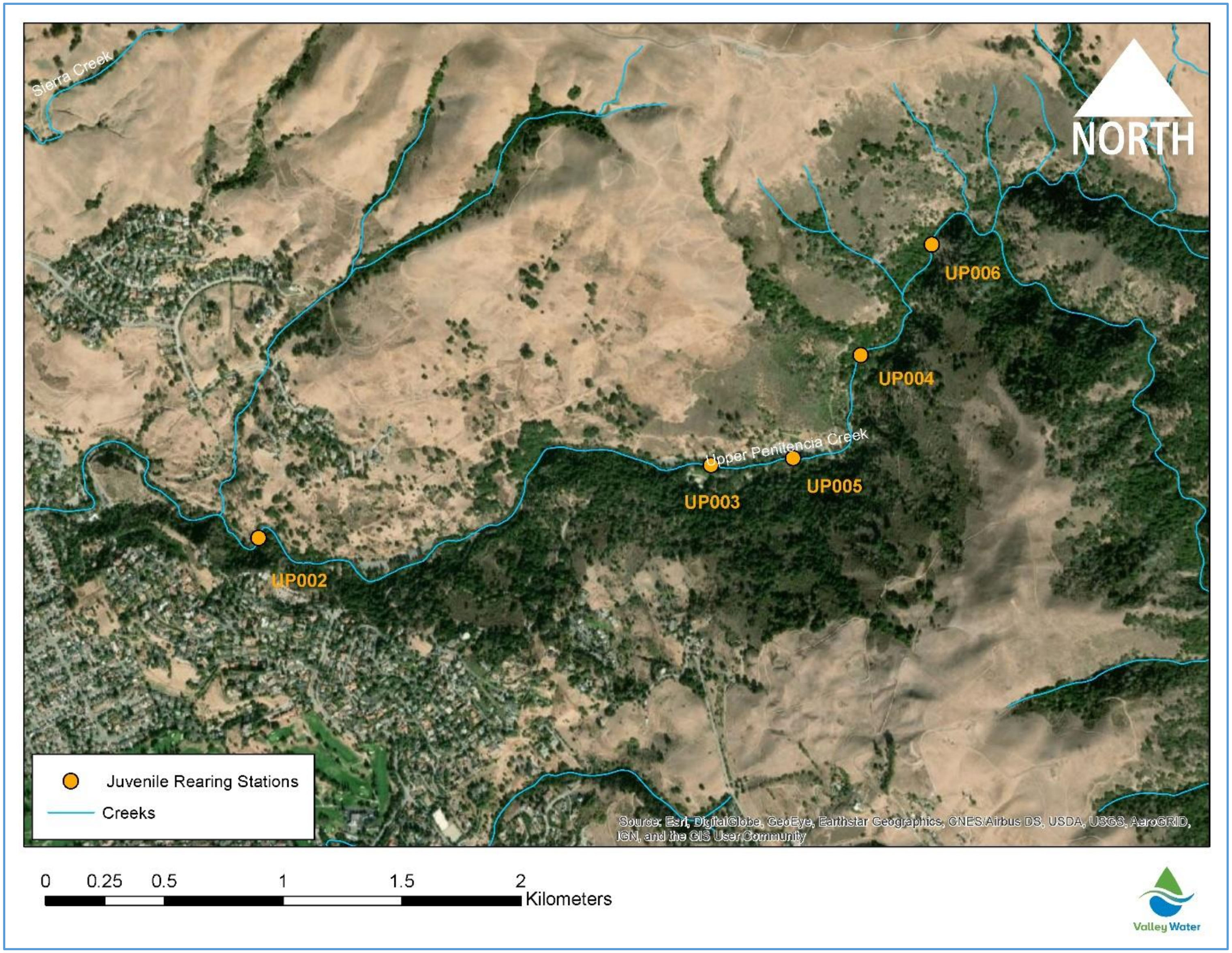

Figure 1: Upper Penitencia Creek juvenile rearing monitoring stations.

2.2 Sampling Methods

Each monitoring station was between 40.0 and 55.0 m in length. The target length was 40.0 m, but deviations in length occurred based on the ability to isolate each reach. Multi-pass depletion backpack electrofishing was deployed at every station (Johnson et al. 2007). This method allowed for consistency with previous juvenile rearing monitoring methods, the extrapolation of population estimates, and the sampling of a variety of habitat types.

Habitat Typing

Each monitoring station was habitat typed using the classifications following Ode (2007) (Table 1). Average wetted width and depth were estimated and the presence of any anthropogenic influences (bridge, dam, etc.) was noted. Prior to the start of sampling, ambient weather conditions were noted and water quality data (dissolved oxygen, conductivity, turbidity, and temperature) was collected at the downstream end of each monitoring station. Ocular estimates of percent cover of macrophytes/emergent vegetation, boulders, woody debris, undercut banks, overhanging vegetation, submerged roots (live and dead), and artificial structures were recorded for each monitoring station. Each habitat feature was ranked on a 0-4 point scale described in Table 2, with 0 being absent and 4 being a very heavy presence. Primary and secondary substrate types were determined based upon ocular estimates (Table 3; Ode 2007).

Table 1: Habitat type classifications (Ode 2007).

Habitat Type	Description
Cascades	Short, high gradient drop in streambed elevation often accompanied by boulders and considerable turbulence.
Falls	High gradient drop in elevation of the streambed associated with an abrupt change in the bedrock.
Rapids	Sections of stream with swiftly flowing water and considerable surface turbulence. Rapids tend to have larger substrate sizes than riffles.
Riffles	Shallow sections where the water flows over coarse streambed particles that create mild to moderate surface turbulence.
Step-Run	A series of runs that are separated by short riffles or flow obstructions that cause discontinuous breaks in slope.
Runs	Sections without flow obstructions. The stream bed is typically even and the water flows faster than it does in a pool.
Glides	A section of stream with little or no turbulence, but faster velocity than pools.
Pool	A reach of stream that is characterized by deep, low-velocity water and a smooth surface.

Table 2: Ocular estimate scale (Ode 2007).

Scale	0	1	2	3	4
Percent Coverage	0%	<10%	10-40%	40-75%	>75%
Descriptor	Absent	Sparse	Moderate	Heavy	Very Heavy

Table 3: Substrate classes (Ode 2007)

Particle Size	Size Category
Boulder	> 250 mm
Cobble	65-250 mm
Gravel	2.0-65 mm
Sand	<2.0 mm (gritty texture)
Silt/Clay	Not gritty
Bedrock	No individual particles

Electrofishing

Due to the low flows at the time of sampling, block nets were not needed as immigration into and emigration out of sampling reaches were naturally blocked by low flow conditions and associated habitat features in the stream. Electrofishing commenced from down to upstream and worked laterally across the channel to ensure all portions of the wetted width were sampled. Smith-Root LR24 Backpack Electrofishing Units were used at all monitoring stations. The LR24 quick set option was used to establish the initial power and waveform settings and verified with conductivity readings. Electrofishers were run using direct current at a frequency of 30 Hz, duty cycle of 12%, and voltage that ranged between 150 and 220 volts (depending on conductivity). Each electrofisher operator was flanked by two netters. Verbal communication and spatial awareness were used to ensure the entire width of the stream was covered. Triple-pass depletion electrofishing methods were deployed at all stations.

Fish Processing

Fish were held in aerated dark-colored containers during processing. Length measurements were recorded to the nearest millimeter at the fork of the tail (fork-length). For each pass, up to 30 individuals of each species were measured, and all other individuals of that species were counted for a total number. All *O. mykiss* were measured.

Carbon dioxide (CO_2) was administered to *O. mykiss* using Alka-Seltzer Gold in doses to induce light narcosis (1 tablet per 2.5 liters of stream water). *O. mykiss* were exposed to the anesthesia for no more than 5 minutes. *O. mykiss* were observed for listing, and upon listing were removed from the anesthetizing solution, weighed, measured, tail-clipped for a genetic sample, and PIT tagged if large enough (≥65 mm fork-length).

Fin clips were taken for genetic analysis of all *O. mykiss* from the caudal fin. Clips were a 1-2 mm square. Medical grade scissors used to collect the clips were sterilized with an alcohol dilution with a final concentration of 60-80% isopropyl. Tissue samples were placed in sterile chromatography paper and then placed in a labeled envelope denoting the field specimen number, species, stream, stream location, date, and fork-length. Tissues collected will be sent to the National Marine Fisheries Service (NMFS) Southwest Fisheries Science Center for analysis.

All PIT tagging was conducted in accordance with the PIT Tag Marking Procedures Manual (CBFWA 1999) by staff trained in the procedure. All *O. mykiss* 65 mm in fork-length or greater received a PIT tag. Biomark single-use preloaded needles were used in the tagging process. Prior to inserting PIT tags, all *O. mykiss* were scanned to ensure they were not previously tagged, and all PIT tags were scanned to verify they were viable. *O. mykiss* greater than or equal to 65 mm fork-length received 12 mm half-duplex PIT tags. *O. mykiss* larger than 150 mm fork-length received 23 mm tags. The permits allow for fish greater than 100 mm to be tagged with 23 mm tags, but to be conservative with the fishes' welfare, the minimum size was increased to 150 mm. PIT tag numbers and associated biological data for each fish is included in Appendix A.

After exposure to the anesthesia and all procedures, fish were placed in an aerated dark-colored receptacle, then transferred to an in-channel live car for recovery, and then released.

2.3 Data Analysis

MicroFish 3.0 was used to calculate population estimates for each station using a maximum-likelihood iterative process (MLIP); the associated standard errors and 95% confidence intervals (95% CI) are reported. This method uses the number of fish captured (n) and the difference in capture between electrofishing passes (i.e., depletion rate) to calculate an estimate of fish likely to have been present but not captured, thus generating a population estimate (N) for each station. Population estimates are restricted to the sampled areas and are only an index of the overall population. If the number of a particular species is too low (i.e., only one fish was captured) or all fish of a particular species are captured on the first pass, then a maximum-likelihood population estimate cannot be produced. If the lower confidence interval was less than the total catch it was set equal to total catch, as it is certain at least that many fish were present in the sampling reach. These calculations assume emigration and immigration were prevented by the isolated reaches. It is assumed that shocking efficiency did not change between passes and that staff did not become more efficient using the equipment, nor did fish learn to avoid the electrical field between passes.

3. Results

Sampling occurred at four stations on Upper Penitencia Creek on August 4 and 5, 2020. All sampling days were sunny and clear. Flows during the sampling events were low and, in some instances, flow limited up and downstream movement of fish. Flows at the time of the sampling were recorded at 0.4 cfs. The nearest gage for accurately describing flow conditions is the ALERT Gage 5083 Upper Penitencia Creek at Dorel Drive. This gage is downstream of three of the four sampling locations.

UP002

This station is located at the downstream extent of the City of San Jose's Alum Rock Park and was sampled in 2019. The surrounding land use is rural park lands with a two-lane road parallel to the creek channel. The monitoring station was 55.0 m in length with an average wetted width of 2.0 m and an average depth of 0.2 m. Three habitat types were present within the station: run, glide, and pool (Figure 2). The pool habitat made up 33% of the sampled reach, the run 31%, and the glide the remaining 36%. The primary substrate was cobble with a secondary substrate of boulder. Results of the water quality monitoring and the ocular assessment of habitat complexity can be seen in Table 4. Issues with the water quality instrumentation calibration lead to dissolved oxygen not being collected. The artificial structure observed was a historical concrete structure on the edge of the channel; these features are common within Alum Rock Park.

Figure 2: Photos of station UP002, looking upstream (left) and looking downstream (right).

Table 4: Upper Penitencia Creek station UP002 water quality data and ocular estimates of habitat complexity.

Water Quality						
Conductivity (µS/cm)	Temperature (°C)	Dissolved Oxygen (mg/L)	Turbidity (NTU)			
1070	17.84	-	15.5			
Habitat Complexity Scoring						
Macrophytes/Emergent Vegetation	**Boulders**	**Woody Debris**	**Undercut Banks**	**Overhanging Vegetation**	**Roots**	**Artificial Structures**
1	3	0	1	1	1	1
Station Measurements						
Wetted Width (m)	**Average Depth (m)**	**Sample Area Length (m)**				
2.0	0.2	55				

Three fish species were captured during the survey: California roach (*Lavinia symmetricus*), riffle sculpin (*Cottus gulosus*), and Sacramento sucker (*Catostomus occidentalis*). Fish captured and associated population estimates are summarized in Table 5. The most abundant species encountered was California roach (n=65). The MLIP indicates the number of California roach and riffle sculpin were likely higher than what was captured. No *O. mykiss* were detected.

Table 5: Number of fish captured and population estimates at station UP002 on Upper Penitencia Creek.

Species	Native	n	N	SE	95% CI
California roach	Yes	65	79	9.64	65-98
Riffle sculpin	Yes	40	48	7.24	40-63
Sacramento sucker	Yes	25	25	0.855	25-27

n = total number captured, N = calculated population estimate, SE = standard error, CI = confidence interval

UP003

This station is located within Alum Rock Park and was sampled in 2019. The surrounding land use consists of a manicured park setting with parking lots, picnic areas, and lawns. The monitoring station was 44.0 m in length with an average wetted width of 5.0 m and an average depth of 0.35 m. Four habitat types were present within the station: step-run, riffle, glide, and pool (Figure 3). Habitat at the station was 32% glide, 32% pool, 29% step-run, and 7% riffle. The primary substrate was cobble with a secondary substrate of boulder. Results of the water quality monitoring and the ocular assessment of habitat complexity can be seen in Table 6. Issues with the water quality instrumentation calibration lead to dissolved oxygen not being collected.

Figure 3: Photos of station UP003, looking upstream (left) and looking downstream (right).

Table 6: Upper Penitencia Creek station UP003 water quality data and ocular estimates of habitat complexity.

<table>
<tr><th colspan="7">Water Quality</th></tr>
<tr><th colspan="2">Conductivity (µS/cm)</th><th colspan="2">Temperature (°C)</th><th colspan="2">Dissolved Oxygen (mg/L)</th><th>Turbidity (NTU)</th></tr>
<tr><td colspan="2">1020</td><td colspan="2">17.45</td><td colspan="2">-</td><td>0.0</td></tr>
<tr><th colspan="7">Habitat Complexity Scoring</th></tr>
<tr><th>Macrophytes/Emergent Vegetation</th><th>Boulders</th><th>Woody Debris</th><th>Undercut Banks</th><th>Overhanging Vegetation</th><th>Roots</th><th>Artificial Structures</th></tr>
<tr><td>2</td><td>4</td><td>1</td><td>1</td><td>3</td><td>1</td><td>0</td></tr>
<tr><th colspan="7">Habitat Measurements</th></tr>
<tr><th colspan="2">Wetted Width (m)</th><th colspan="3">Average Depth (m)</th><th colspan="2">Sample Area Length (m)</th></tr>
<tr><td colspan="2">5</td><td colspan="3">0.35</td><td colspan="2">44</td></tr>
</table>

Four fish species were captured during the survey: *O. mykiss*, California roach, riffle sculpin, and Sacramento sucker. Fish captured and associated population estimates are summarized in Table 7. The most abundant species encountered was riffle sculpin (n=38), followed by California roach (n=37). Two *O. mykiss* were captured and PIT tagged prior to being released. The MLIP indicates that the number of California roach is likely higher than what was captured. A more detailed analysis of the *O. mykiss* capture results is provided in Section 4 (Discussion).

Table 7: Number of fish captured and population estimates at station UP003 on Upper Penitencia Creek.

Species	Native	n	N	SE	95% CI
California roach	Yes	37	67	34.86	37-137
O. mykiss	Yes	2	2	0.00	2-2
Riffle sculpin	Yes	38	38	0.88	38-40
Sacramento sucker	Yes	3	3	1.27	3-8

n = total number captured, N = calculated population estimate, SE = standard error, CI = confidence interval

UP004

This station is located within Alum Rock Park and was sampled in 2019. The station is situated amongst rural park lands. Hiking and walking trails border the creek in this area. The monitoring station was 42.0 m in length with an average wetted width of 5.0 m and an average depth of 0.25 m. Two habitat types were present within the station: pool and step-run (Figure 4). Habitat at the station was 38% pool and 62% step-run. The primary substrate was cobble with a secondary substrate of boulder. Results of the water quality monitoring and the ocular assessment of habitat complexity can be seen in Table 8. Issues with the water quality instrumentation calibration lead to dissolved oxygen not being collected.

Figure 4: Photos of station UP004, looking upstream (left) and looking downstream (right).

Table 8: Station UP004 water quality data and ocular estimates of habitat complexity.

Water Quality			
Conductivity (µS/cm)	**Temperature (°C)**	**Dissolved Oxygen (mg/L)**	**Turbidity (NTU)**
455	16.5	-	5.5

Habitat Complexity Scoring						
Macrophytes/Emergent Vegetation	**Boulders**	**Woody Debris**	**Undercut Banks**	**Overhanging Vegetation**	**Roots**	**Artificial Structures**
1	4	1	1	2	1	0

Habitat Measurements		
Wetted Width (m)	**Average Depth (m)**	**Sample Area Length (m)**
5	0.25	42

Three fish species were captured during the survey: *O. mykiss*, California roach, and riffle sculpin. The most abundant species encountered was riffle sculpin (n=131), followed by California roach (n=42). All 5 of the *O. mykiss* were ≥65 mm, and thus were PIT tagged prior to being released. Fish captured and associated population estimates are summarized in Table 9. For California roach and riffle sculpin, the MLIP indicates that the number of individuals captured in the reach is likely higher than what was observed. A more detailed analysis of the *O. mykiss* capture is provided in Section 4 (Discussion).

Table 9: Number of fish captured and population estimates at station UP004 on Upper Penitencia Creek.

Species	Native	n	N	SE	95% CI
California roach	Yes	42	46	3.82	42-54
O. mykiss	Yes	5	5	0.17	5-5
Riffle sculpin	Yes	131	162	14.84	131-191

n = total number captured, N = calculated population estimate, SE = standard error, CI = confidence interval

UP005

This station was sampled for the first time in 2020 and is located between station UP003 and UP004 in Alum Rock Park. The station is situated amongst rural park lands. Hiking and walking trails border the creek in this area. The monitoring station was 43.0 m in length with an average wetted width of 3.5 m and an average depth of 0.2 m. Three habitat types were present within the station: riffle, run, and pool (Figure 5). Riffle habitat made up 37% of the sampled area, followed by run habitat at 33%, with pool habitat making up the remaining 30%. The primary substrate was cobble with a secondary substrate of boulder. Results of the water quality monitoring and the ocular assessment of habitat complexity can be seen in Table 10. Issues with the water quality instrumentation calibration lead to dissolved oxygen not being collected.

Figure 5: Photos of station UP005, looking upstream (left) and looking downstream (right).

Table 10: Station UP005 water quality data and ocular estimates of habitat complexity.

Water Quality			
Conductivity (µS/cm)	Temperature (°C)	Dissolved Oxygen (mg/L)	Turbidity (NTU)
980	16.69	-	0.0

Habitat Complexity Scoring						
Macrophytes/Emergent Vegetation	Boulders	Woody Debris	Undercut Banks	Overhanging Vegetation	Roots	Artificial Structures
2	4	1	1	3	1	1

Habitat Measurements		
Wetted Width (m)	Average Depth (m)	Sample Area Length (m)
3.5	0.2	43

Four fish species were captured during the survey: *O. mykiss*, California roach, riffle sculpin, and Sacramento sucker. The most abundant species encountered was riffle sculpin (n=105). Fish captured and associated population estimates are summarized in Table 11. The MLIP indicates that the number of California roach and riffle sculpin is likely higher than what was captured. The two *O. mykiss* captured were ≥65 mm, and thus were PIT tagged prior to being released. A more detailed analysis of the *O. mykiss* capture is provided in Section 4 (Discussion).

Table 11: Number of fish captured and population estimates at station UP005 on Upper Penitencia Creek.

Species	Native	n	N	SE	95% CI
California roach	Yes	38	52	13.22	38-79
O. mykiss	Yes	2	2	0.38	2-7
Riffle sculpin	Yes	105	107	1.98	105-111
Sacramento sucker	Yes	18	18	0.25	18-19

n = total number captured, N = calculated population estimate, SE = standard error, CI = confidence interval

UP006

This station was sampled for the first time in 2020 and was the most upstream station sampled. The station is situated amongst rural park lands, and hiking and walking trails border the creek in this area. The monitoring station was 42.0 m in length with an average wetted width of 5.0 m and an average depth of 0.25 m. Two habitat types were present within the station: step-run and pool (Figure 6). Step-run habitat made up 62% and pool habitat made up the remaining 38%. The primary substrate was cobble with a secondary substrate of boulder. Results of the water quality monitoring and the ocular assessment of habitat complexity can be seen in Table 12. Issues with the water quality instrumentation calibration lead to dissolved oxygen not being collected.

Figure 6: Photos of station UP006, looking upstream (left) and looking downstream (right).

Table 12: Station UP006 water quality data and ocular estimates of habitat complexity.

Water Quality			
Conductivity (µS/cm)	**Temperature (°C)**	**Dissolved Oxygen (mg/L)**	**Turbidity (NTU)**
455	16.5	-	3.1

Habitat Complexity Scoring						
Macrophytes/Emergent Vegetation	**Boulders**	**Woody Debris**	**Undercut Banks**	**Overhanging Vegetation**	**Roots**	**Artificial Structures**
1	4	1	1	2	1	0

Habitat Measurements		
Wetted Width (m)	**Average Depth (m)**	**Sample Area Length (m)**
5	0.25	42

Two fish species were captured during the survey: *O. mykiss* and riffle sculpin. The most abundant species encountered was *O. mykiss* (n=6). Fish captured and associated population estimates are summarized in Table 13. The MLIP indicates that the number of individuals is not likely higher than what was captured. The six *O. mykiss* captured were ≥65 mm, and thus were PIT tagged prior to being released. A more detailed analysis of the *O. mykiss* capture is provided in Section 4 (Discussion).

Table 13: Number captured and population estimates at station UP006 on Upper Penitencia Creek.

Species	Native	n	N	SE	95% CI
O. mykiss	Yes	6	6	1.38	6-10
Riffle sculpin	Yes	4	4	0.00	4-4

n = total number captured, N = calculated population estimate, SE = standard error, CI = confidence interval

4. Conclusion

A total of 15 *O. mykiss* were collected among the four most-upstream stations. The reason for the declining trend in *O. mykiss* abundance as monitoring stations moved downstream is unknown. The physical habitat conditions present at all sites appeared suitable to support *O. mykiss*. Notably, Alum Rock Park and Upper Penitencia Creek contain unique geological formations, and mineral spring seeps release minerals such as sulfur, sodium chloride, magnesium, iron, and calcium carbonate into the waters of Upper Penitencia Creek. Stations UP004 and UP006 (the stations with the highest number of *O. mykiss* captured) were located above most of these seeps, therefore it is possible that the change in water chemistry is altering the distribution of *O. mykiss*. This could be especially true during the low flow conditions that were present during the sampling period.

The average *O. mykiss* density (fish per meter) for all 2020 monitoring stations in Upper Penitencia Creek was 0.05 fish per meter (based on the number of fish caught [n]). The O. mykiss density at each station for 2019 and 2020 can be seen in Figure 7 below.

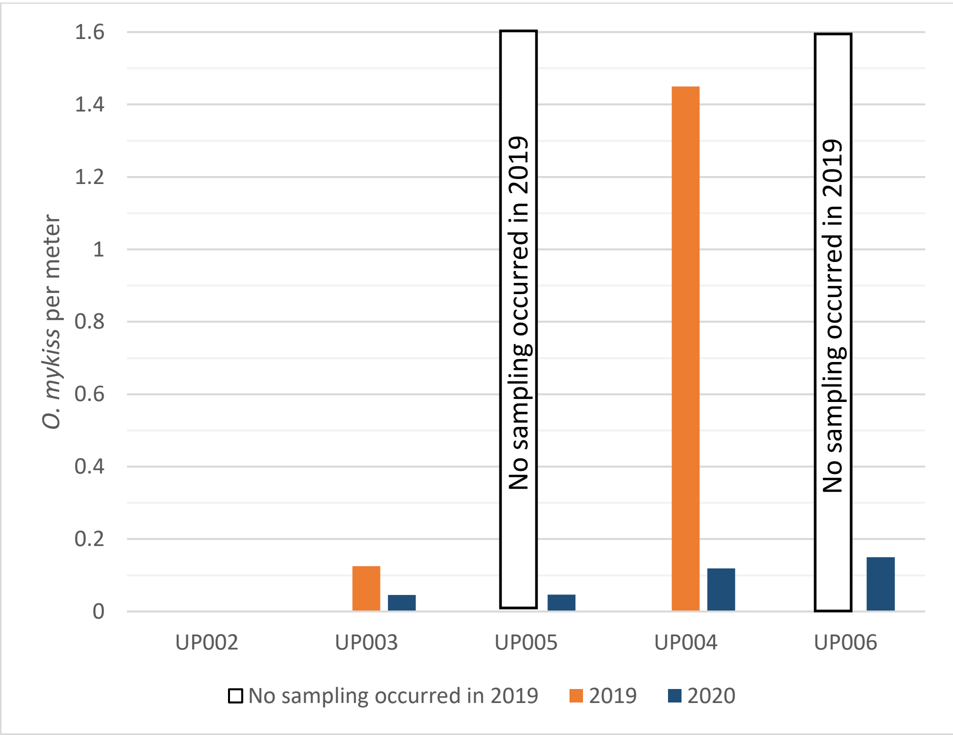

Figure 7: Observed *O. mykiss* densities at the five monitoring stations on Upper Penitencia Creek in 2019 and 2020 (No sampling occurred at UP005 and UP006 in 2019 and no *O. mykiss* have been captured at UP002 in any year).

O. mykiss fork-lengths ranged from 104 mm to 248 mm in 2020 (Figure 8). Growth rates of juvenile *O. mykiss* in California are highly variable and are dependent on temperature, food availability, seasonal flow, and population densities/competition (Moyle 2002). According to Moyle (2002), in small streams with low summer flows, such as Upper Penitencia Creek, young-of-the-year steelhead measure 50–90 mm, and fish at the end of their second year measure 100–160 mm. Smith (2018) aged fish from

Upper Penitencia Creek between 2011 and 2018 and found that young-of-the-year *O. mykiss* ranged from 80–144 mm, while fish in their second year ranged from 85–229 mm and fish in their third year 205-359 mm. This is a faster growth rate than predicted by Moyle (2002). It's important to note that fish captured in water year 2020 were measured in early August, the size ranges reported by Moyle are from the end of the first year of growth (spring) and in the fall in the Smith study. Based on Smith (2018) growth rates, *O. mykiss* captured in Upper Penitencia Creek in water year 2020 were a mix of fish ranging from potentially young-of-the-year or fish in their first year to fish in their second and third year. Based on Moyle (2002), these *O. mykiss* would all be at least in their second year of growth. Based on the study by Smith (2018), 7 of the 15 fish captured could potentially be young of the year or in their second year as they fall within the 80-144 mm and the 85-229 mm range defined in the study. It appears there is significant overlap in sizes of each age class, and with the seasonal timing of sampling it is difficult to draw any conclusions. More analysis needs to be conduct on age distribution within Upper Penitencia Creek. One fish that was tagged in 2019 was a recapture that measured 234 mm last year, indicating it was at least 1+, and 248 mm at the time of capture in 2020.

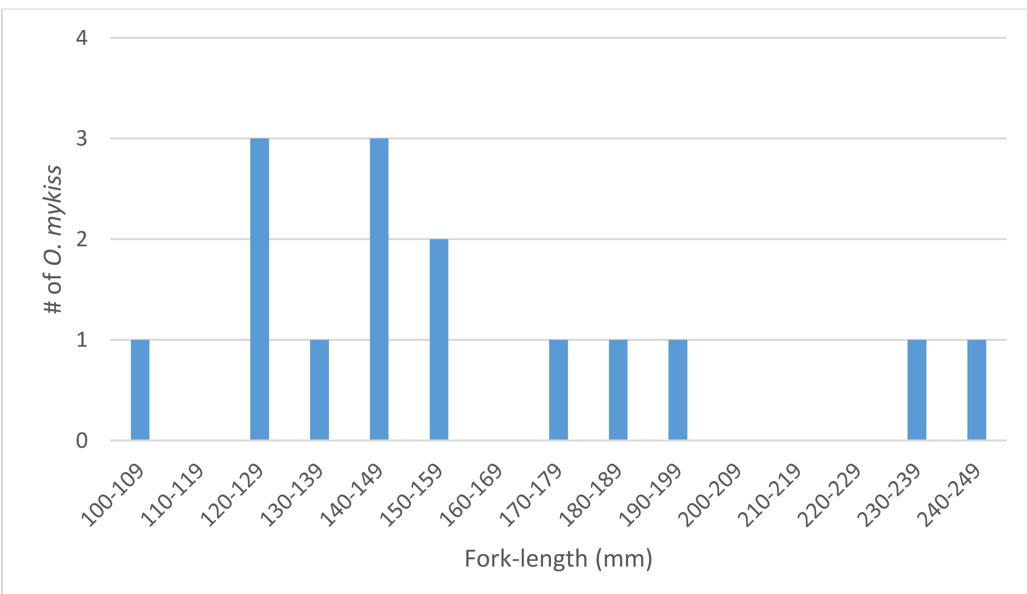

Figure 8: 2020 Upper Penitencia Creek *O. mykiss* fork-lengths. Measurements are binned in 10 mm increments.

In 2020, juvenile *O. mykiss* were observed in Upper Penitencia Creek. The average densities and median fork-length of *O. mykiss* detected in both 2019 and 2020 can be seen in Table 14. There was a higher density of *O. mykiss* in 2019, and the median fork-length was lower than in 2020. Figure 9 shows the size distribution of all *O. mykiss* collected in Upper Penitencia Creek between 2019 and 2020. The median fork-length of *O. mykiss* captured in 2020 was 147 mm, which is much higher than the median fork-length of 92 mm captured in 2019 (Table 14). Based on the higher fork-lengths captured in 2020, it appears that the young of the year had lower survival in 2020 compared to 2019 or production was lower.

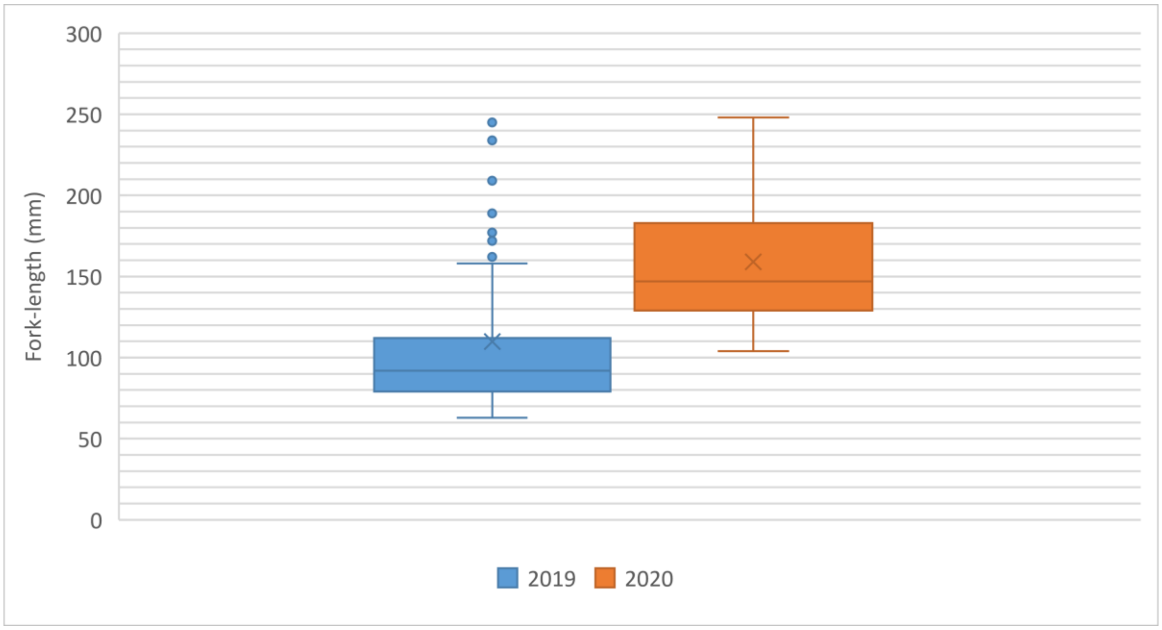

Figure 9: 2019 and 2020 *O. mykiss* size distribution (fork-length) in Upper Penitencia Creek. First and third quartiles (lower and upper box boundaries, respectively), median (line inside box), mean (x symbol), highest and lowest points within 1.5 times the interquartile range (upper and lower whiskers, respectively), and outlier points that fall outside the 1.5 times the interquartile range (filled circles).

The average *O. mykiss* density for the five monitoring stations sampled in 2020 was 0.05 fish per meter in 2020 and was 0.39 fish per meter in 2019 (Table 14). It is unclear what caused the significant reductions in *O. mykiss* numbers in 2020, but it is possible that abundance was impacted by a poor water year with lower flow conditions.

Table 14: 2019 and 2020 average density and median fork-length of *O. mykiss* captured within Upper Penitencia Creek.

Year	***O. mykiss*/meter**	**Median Fork-length (mm)**
2019	0.39	92
2020	0.05	147

Of the 15 *O. mykiss* captured, 4 had a Neascus-type parasitic infection commonly called “blackspot” disease. The visible black spots associated with fish are the metacercaria stage of the free-swimming parasite that produce a melanin-induced fibrous cyst (Schaaf et al. 2017). A severity scale ranging from Level 1 to Level 3 was developed to denote the degree of infection; Level 1 being low severity, Level 2 being moderate, and Level 3 being severe. Two of the *O. mykiss* were classified as having a Level 1 infection with only a few raised cysts. One *O. mykiss* was classified with a Level 2 infection and one *O. mykiss* with a Level 3 infection (raised cysts present on greater than 25% of the body). The impacts to *O. mykiss* associated with this infection are not known. In 2019, 4 of the 63 *O. mykiss* captured were visibly infected with black spot, and all of the infected fish were classified with a Level 1 infection. In 2020, 4 of the 15 *O. mykiss* captured were visibly infected with black spot; 2 were classified as Level 1, 1 as Level 2, and 1 as Level 3. It is unclear whether blackspot is spreading and/or worsening throughout Upper Penitencia Creek, or if the increased prevalence and severity of blackspot recorded this year is due to lower flow conditions that may reduce the ability of *O. mykiss* to fight off infection.

Four species of native fish were observed on Upper Penitencia Creek at all five selected monitoring stations. No non-native species were captured. The most-downstream station did not detect *O. mykiss*; however, species commonly associated with *O. mykiss* and that share similar habitat requirements were encountered, indicating that the habitat is suitable for *O. mykiss*. It is difficult to assess any trends at this time, but a better understanding of *O. mykiss* abundance and migration in the Coyote Creek Watershed will develop as more data becomes available through continued electrofishing sampling and PIT antenna stations.

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2020 Upper Penitencia Creek
Juvenile *Oncorhynchus mykiss* Fish Condition

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Contents

Tables

Figures

Appendices

Background

Fish condition is a measure of length and weight that represents the physiological or nutritional state of a fish and can be used to compare the effects of biotic and abiotic factors on the health of a population (Murphy et al. 1990, Cone 1989). For instance, the presence of generally plump fish may be indicative of favorable environmental conditions (high-quality habitat, ample prey availability, etc.), whereas thin fish may indicate less favorable conditions. Therefore, monitoring fish condition can be useful for informing management recommendations concerning fish populations.

Relationships between weight and length are often used for assessing population size structure and individual fish condition. Because fish weight is directly related to fish length, weight-length data is not only used to predict one from the other, but it can also be used as an indicator of an individual's fatness or condition by measuring the variation from the expected weight for a certain length (LeCren 1951). The traditional approach to assessing fish condition involves the use of a 'condition factor,' which employs a fixed ratio to describe the relationship between fish length and weight (Murphy et al. 1991). The commonly used Fulton's condition factor (K) (Fulton 1904) is calculated as:

$$K = W / L^3$$

Where W is weight and L is length. Though it has the advantage of being easy to calculate, Fulton's condition factor has its drawbacks. First, it assumes isometric growth (power = 3, fish shape does not change with growth), which is rarely the case for most fish species (Froese 2006). Second, it is highly length- and species-dependent; therefore, it can only be reliably used to compare individuals with similar lengths and is practically impossible to compare across species. LeCren (1951) developed the relative condition factor (K_n) to address these issues, which is calculated with the formula:

$$K_n = W / W' \times 100$$

Where W is the actual weight of the individual fish and W' is the predicted length-specific mean weight for the population under study. While this approach solved the problem of comparing fish of different lengths and species, it is population-dependent and thus cannot be used to compare fish condition across populations.

The concept of ‘relative weight’ as a condition index was first introduced by Wege and Anderson (1978) for measuring the condition of largemouth bass (*Micropterus salmoides*). The relative weight approach compares fish weight to a benchmark, or standard weight, of that species based on weight-length data collected throughout its range. Wege and Anderson believed that relative weight had several advantages over other condition factors: 1) it is easy to calculate, 2) relative weight does not change with different units of measure, 3) standard weights compensate for inherent changes in body form, and 4) relative weight values can be compared between fish of different lengths and from different populations (Blackwell et al. 2000). For these reasons, the relative weight index has become widely used in recent years as a measure of fish condition.

Introduction

The Coyote Creek Watershed is the largest watershed in Santa Clara County, encompassing over 829 square kilometers. The eastern and southern portions of the watershed drain most of the western face of the Diablo Mountain Range where the creek originates at elevations up to 1,110 meters. These upper watershed areas remain undeveloped with little anthropogenic disturbance. The northern and western portions of the watershed are comprised of the Santa Clara County valley floor. Portions of the valley floor are extensively urbanized with patches of undeveloped parks and open agricultural lands. Coyote Creek has 29 tributaries and flows northwest through the valley, approximately 68 kilometers from the headwaters, where it enters the southern extent of the San Francisco Bay.

The Coyote Creek Watershed supports the federally threatened Central California Coast (CCC) steelhead (*Oncorhynchus mykiss*) Distinct Population Segment (DPS). Two systems in the Coyote Creek Watershed are designated as critical habitat for *O. mykiss*: Coyote Creek and Upper Penitencia Creek. Coyote Creek critical habitat extends from the creek's confluence with the San Francisco Bay to the base of the Leroy Anderson Dam, and Upper Penitencia Creek critical habitat extends from the creek's confluence with Coyote Creek to the base of the dam at Cherry Flat Reservoir. Though critical habitat extends to the base of Cherry Flat Reservoir, an impassable natural waterfall is located approximately 3.5 km downstream of the dam.

In August of 2020, Valley Water conducted index reach monitoring for juvenile *O. mykiss* in Upper Penitencia Creek. To better understand the health of juvenile *O. mykiss* in this system, fish condition was analyzed for individuals sampled during the 2020 monitoring effort. The relative weight approach was used to evaluate fish condition due to the utility and ease with which it can be calculated and analyzed.

Methods

Data Collection

In summer 2020, length-weight data was collected from juvenile *O. mykiss* sampled during Valley Water's Upper Penitencia Creek index reach monitoring effort. The purpose of this annual monitoring effort, which began in Upper Penitencia Creek in 2019, is to document the abundance, distribution, and densities of *O. mykiss*. For details on data collection methods, including sampling sites and fish processing procedures, please refer to the 2020 Juvenile *Oncorhynchus mykiss* Rearing Monitoring in Upper Penitencia Creek report (Valley Water 2021).

Calculations

The standard weight for each fish was calculated from their measured length using the following standard weight equation developed for juvenile *O. mykiss* ranging from 50 to 200 mm fork-length (Duffy 2006):

$$\log_{10}W_s = -4.790 + 2.928\log_{10}FL$$

Where W_s is the standard weight in grams and FL is the fork-length in millimeters. This standard weight equation was developed using weight-length data from 121 *O. mykiss* populations ranging from southern Alaska through central California (Duffy 2006), including populations within the CCC DPS. The equation was formed using the regression-line-percentile technique (Murphy et al. 1990), which is based on 75th-percentile weights and uses $\log_{10}$ transformed data from a series of populations as the statistical population to be modeled (Blackwell et al. 2000).

The slope of the standard weight equation (b = 2.928) developed by Duffy (2006) indicates that juvenile *O. mykiss* ranging from Alaska to central California exhibit slight negative allometric growth (they become more elongated as they grow, $b < 3$), which defies the assumption of Fulton's condition factor of $b = 3$. In contrast, when $b > 3$, a fish experiences positive allometric growth and increases more in weight than predicted by its increase in length (it becomes more rounded as it grows) (Froese et al. 2011).

Standard weight was then used to calculate relative weight of individuals with the equation:

$$W_r = (W / W_s) \times 100$$

Where W_r is the relative weight and W is the weight of the fish being compared in grams. The factor 100 is used to express the equation as a percentage of W_s. Note that once $\log_{10}W_s$ was determined for each fish using the standard weight equation, the antilog of these values was used in the above equation to calculate W_r.

Lastly, individuals were categorized into 25-mm fork-length classes (hereafter referred to as length classes) in order to analyze for any length-related condition trends in the population sampled (Blackwell et al. 2000). The Kruskal-Wallis test was used to determine if there were statistically significant differences in W_r between length classes ($p < 0.05$). The Kruskal-Wallis test, considered the nonparametric alternative to the one-way ANOVA, was used for this study due to the non-normal data distributions and small sample sizes.

Relative Weight Target Range

The regression-line-percentile technique used to develop the standard weight equation above uses 75th-percentile weights; therefore, a W_r value of 100 (the actual weight of the fish equals the standard weight) is not an average-sized fish. Rather, it means that across their range, 25% of the juvenile *O. mykiss* will have a W_r value greater than 100 while 75% will be less than 100. A fish with a W_r of 100 is thus considered to be in better-than-average condition. For the original development of the W_r index (Wege and Anderson 1978), 75th-percentile weights were also used as a standard. Anderson (1980) subsequently recommended that 95−105 be used as a W_r target range in order to aim for fish populations that are in above average condition, and it has since been widely used by fisheries managers.

Nonetheless, Murphy et al. (1991) cautioned against using a universal target range for optimal condition, believing that "optimal" will vary according to specific management objectives and environmental limitations. Targets for W_r should therefore be established according to the management goals for a given program, but further research is needed to evaluate appropriate W_r target ranges for juvenile *O. mykiss* populations under various management scenarios.

For the purposes of this report, the W_r target range of 95−105 (Anderson 1980) was used to define fish in optimal condition. This W_r target range may be modified in the future as more data is collected and as management objectives for Upper Penitencia Creek become established.

Interannual Comparison

Juvenile *O. mykiss* were also sampled in Upper Penitencia Creek in November of 2019 (Valley Water 2020), and the population W_r of juvenile *O. mykiss* was compared between 2019 and 2020 to evaluate for any fish condition changes over time. Statistical significance was tested using a Kruskal-Wallis test. Though seasonal variation between sampling periods (fall in 2019 versus summer in 2020) reduced the ability to directly compare results, the evaluation still provided insight into interannual changes in fish condition.

Results

Relative Weight Analysis

Fifteen *O. mykiss* were sampled during the 2020 Upper Penitencia Creek juvenile rearing monitoring season. Measured weights ranged from 22.2 to 172.8 g with a mean weight of 59.5 g (SD=48.2). Measured fork-lengths ranged between 104 and 248 mm with a mean fork-length of 159.0 mm (SD=41.9).

The standard weight equation developed by Duffy (2006) applies to juvenile *O. mykiss* between 50 and 200 mm fork-length. Two *O. mykiss* sampled from Upper Penitencia Creek had a fork-length greater than 200 mm and were therefore excluded from the relative weight analysis. In addition, four individuals were not weighed, and therefore their relative weight could not be assessed. Relative weight of the sampled population which could be analyzed (9 individuals) ranged from 92.8 to 109.1 with a mean W_r of 100.2 (SD=6.0) (Figure 1). Of the 9 *O. mykiss* analyzed, four individuals fell within the 95−105 optimal range, two fish were below 95, and three were above 105.

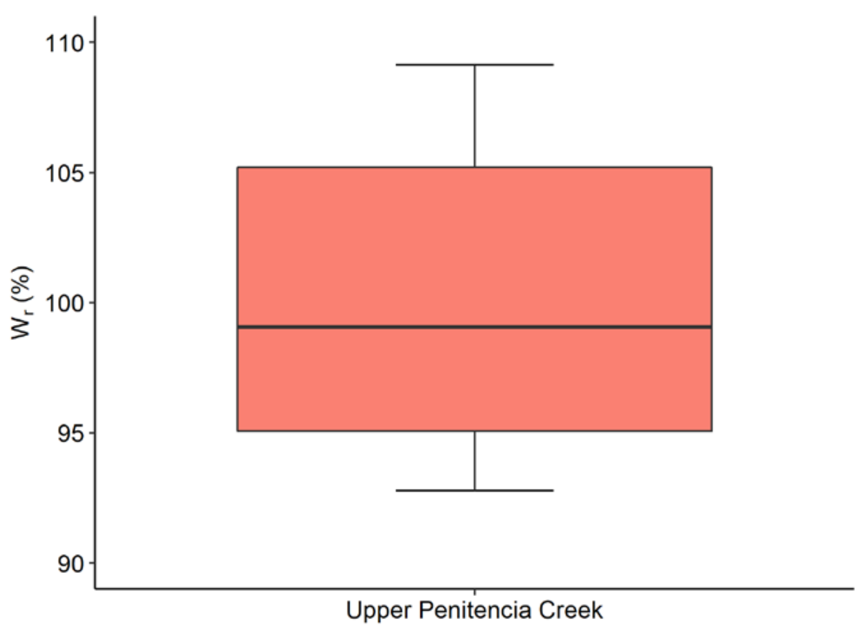

Figure 1. Boxplot (with the median, 25% and 75% quartiles, and whiskers extending 1.5 times the interquartile ranges) of juvenile *O. mykiss* relative weights (W_r) for Upper Penitencia Creek (n = 9).

Relative weight plotted as a function of fork-length revealed an inverse relationship between the two variables, and the effect of fork-length on W_r was statistically significant based on a linear regression analysis (adjusted $R^2 = 0.4687$, 95% CI [-0.33, -0.03], $p = 0.025$) (Figure 2). Summary statistics for W_r per 25-mm length class are provided in Table 1 and distributions are shown in Figure 3. There were no statistically significant differences in mean W_r among length classes as determined by a Kruskal-Wallis test ($H = 5.7$, df = 3, $p = 0.127$).

Individual fish measurements, W_s, and W_r are provided in Appendix A.

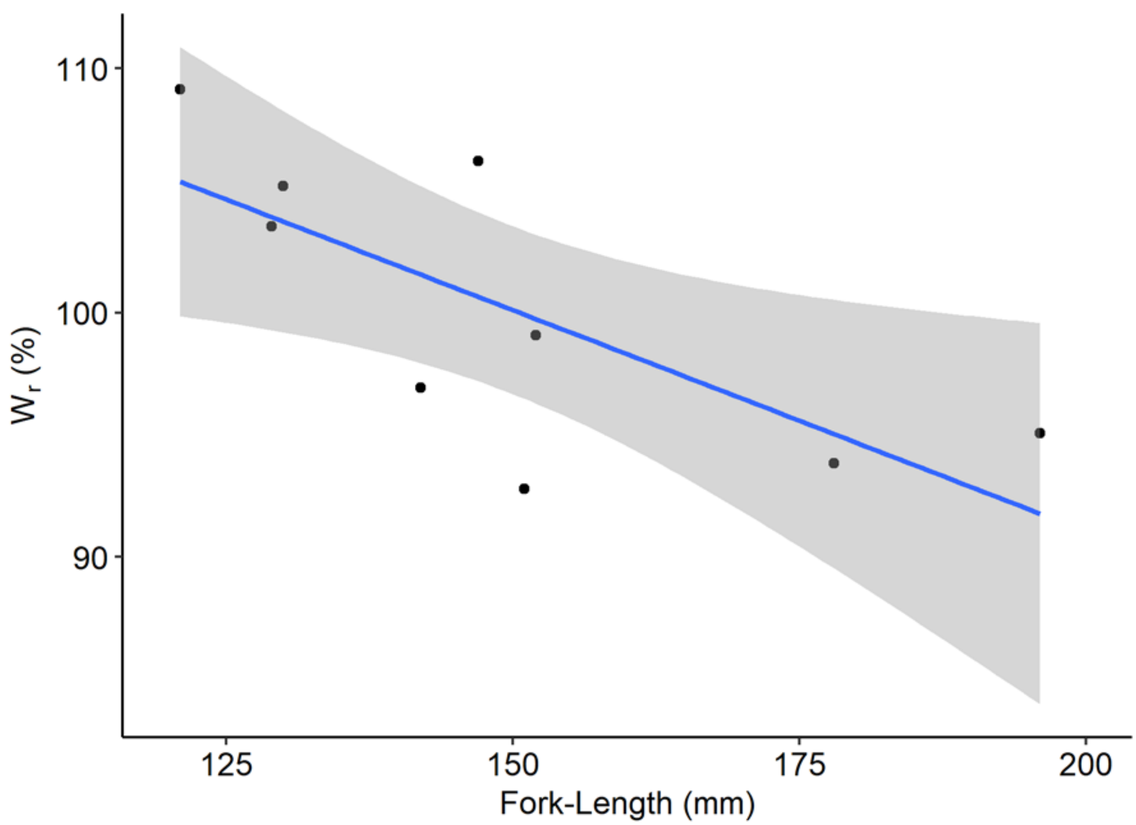

Figure 2. Relative weight (W_r) as a function of fork-length for juvenile *O. mykiss* sampled in Upper Penitencia Creek. Regression line in blue with confidence bands in gray.

Table 1. Summary statistics of Upper Penitencia Creek juvenile *O. mykiss* relative weights (W_r) per 25-mm length class. Means are presented as the value ± SD. Sample size = n.

Length Class (mm)	**n**	**Mean W_r (%)**	**W_r Range (%)**
101-125	1	109.13	109.13
126-150	4	102.96 ± 4.18	96.92−106.21
151-175	2	95.93 ± 4.45	92.78−99.07
176-200	2	94.46 ± 0.88	93.83−95.08

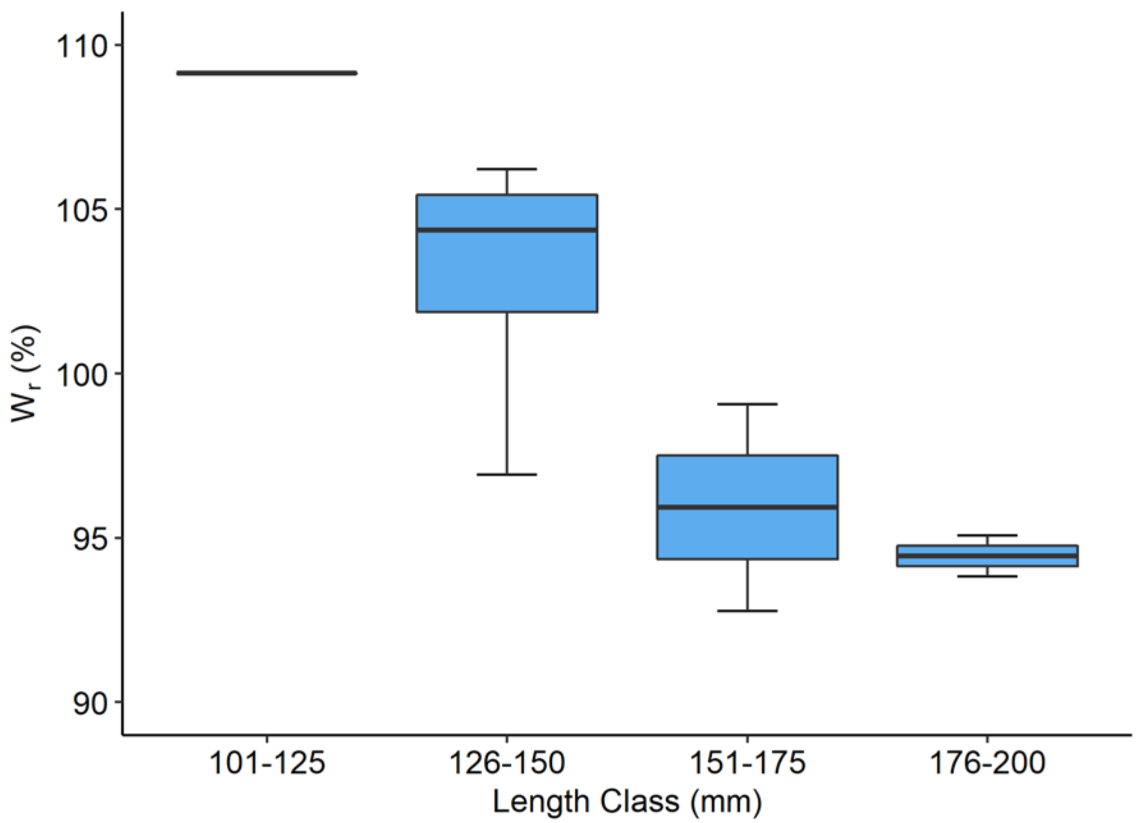

Figure 3. Boxplots (with the median, 25% and 75% quartiles, whiskers extending 1.5 times the interquartile ranges representing Upper Penitencia Creek juvenile *O. mykiss* relative weights (W_r) per 25-mm length class.

Interannual Comparison

Mean W_r was higher in 2019 (111.0 ± 15.3) than in 2020 (100.2 ± 6.0), and the difference in mean W_r between years was statistically significant based on a Kruskal-Wallis test ($H = 5.8$, df = 1, $p = 0.016$). The distributions of W_r for each year are shown in Figure 4.

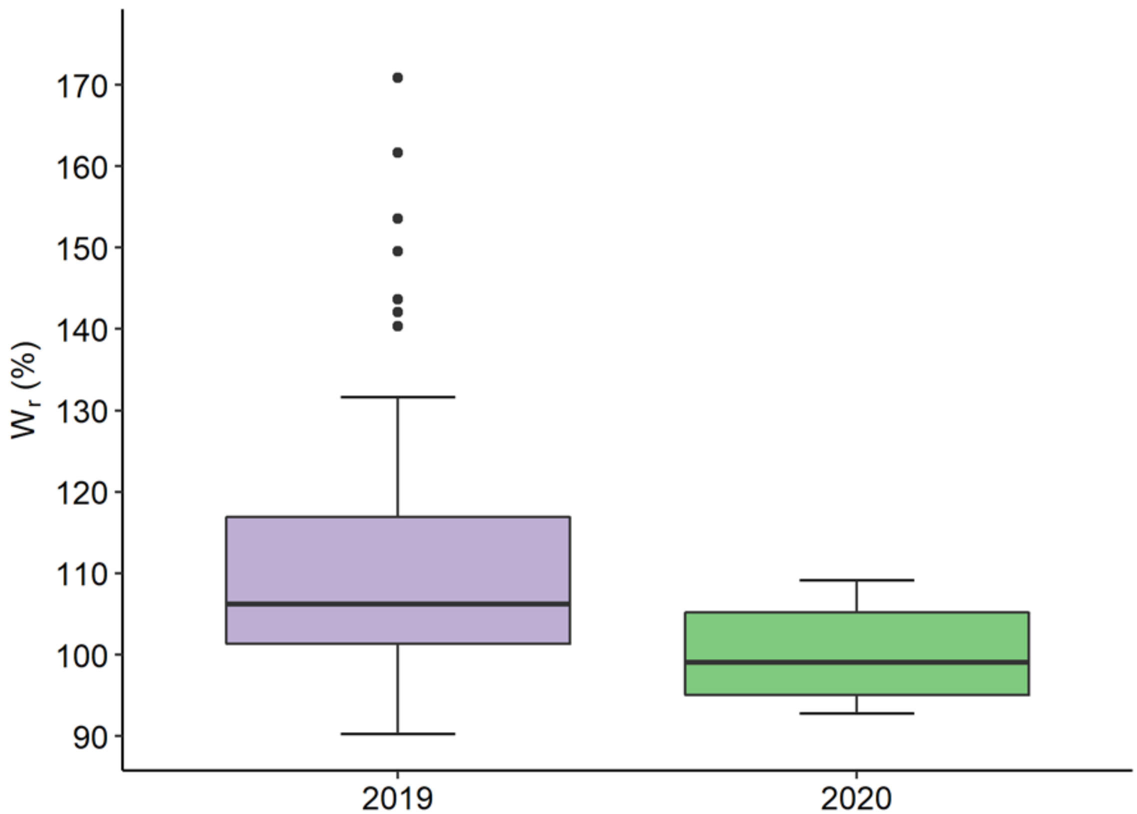

Figure 4. Boxplots (with the median, 25% and 75% quartiles, whiskers extending 1.5 times the interquartile ranges, and outlying points beyond whiskers) of relative weights (W_r) for juvenile *O. mykiss* sampled in Upper Penitencia Creek in 2019 (n = 88) and 2020 (n = 9).

Discussion

Our results show that there were no significant differences in W_r among length classes for juvenile *O. mykiss* sampled in Upper Penitencia Creek in 2020. This suggests that juvenile *O. mykiss* condition did not differ substantially between fish of varying lengths/ages, but the small sample sizes for each length class should be considered when interpreting these results. Relative weight was negatively correlated with fork-length, indicating that the condition of juvenile *O. mykiss* in this system may decline as fish become larger. This trend was also observed in *O. mykiss* sampled in Upper Penitencia Creek in 2019. Nevertheless, conclusions cannot reliably be made at this time as 2020 was only the second year of sampling in this system and because the sample size in 2020 was quite small (n = 9). As more data is collected over the years, any length-related trends in fish condition will become more apparent.

Relative weight values indicate that juvenile *O. mykiss* in Upper Penitencia Creek are overall in healthy condition with 78% of the sampled population (excluding fish >200 mm fork-length and fish that were not weighed) falling either within or above the optimal W_r target range of 95−105. Fish with an optimal W_r can signify a waterbody with conditions ideal for growth, such as suitable habitat and water quality and abundant prey (Murphy et al. 1990, Liao et al. 1995). Presence of physical habitat features like large woody debris and undercut banks can contribute to improved juvenile *O. mykiss* condition and survival by providing refugia from predators and high flow velocities. Water temperature can likewise influence fish condition and has been documented to impact growth and size of *O. mykiss* and other salmonids through effects on metabolism, behavior and mortality (Bjornn and Reiser 1991). Young of the year *O. mykiss* fed to satiation exhibited increased growth rates at increased temperatures (up to 19º C) in a laboratory setting (Myrick and Cech 2005), and increased fall-spring temperatures (maximum temperature was approximately 11º C) were also shown to result in increased growth in *O. mykiss* (Railsback and Rose 1999). However, at extreme upper temperatures, growth may be reduced (Bjornn and Reiser 1991). According to NFMS (2016), optimal water temperatures for juvenile *O. mykiss* growth range from 12 to 19°C (~54 to 66°F), though the majority of research done on suitable temperatures for salmonids has been conducted in the Pacific Northwest where environmental conditions are much different than the Central California Coast. Earlier studies have also found relationships between W_r and food supply (Flickinger and Bulow 1993, Liao et al. 1995) and shown that prey biomass is positively correlated with fish condition.

Our W_r results suggest that environmental conditions in Upper Penitencia Creek are favorable for juvenile *O. mykiss.* Upper Penitencia Creek is known to have habitat complexity in the form of large woody debris, boulders, rootwads, undercut banks, and emergent vegetation (Valley Water 2021), and stream temperatures in this region are within the range defined by NMFS (2016) for most of the year (excluding summer). Though no studies on *O. mykiss* prey abundance have been conducted in Upper Penitencia Creek, our W_r results imply that adequately-sized prey items are readily available.

Additionally, previous studies on salmonids have shown that fish weight or growth is inversely related to population density (Close and Anderson 1992, Keeley 2003), and that mean population W_r values are higher in areas where low densities of fish occur (Johnson et al. 1992). This is because individual fish weight and condition are likely to improve when there is reduced competition for food and other resources. During 2020 sampling, the estimated *O. mykiss* population density in Upper Penitencia Creek was fairly low at 0.05 *O*. *mykiss*/meter (Valley Water 2021) and may be a contributing factor to high W_r in the system. However, the estimated density in 2019 was 0.39 *O*. *mykiss*/meter and fish were also in healthy condition. More reliable conclusions regarding the influence of density on fish condition can be made as sampling continues.

It is worth noting that human error has the potential to skew the results. Accurately measuring the length and weight of fish can be difficult in the field, especially with small fish and when they need to be measured quickly. Furthermore, issues taring the scale in the field and excess water on the equipment (scale and measuring board) can affect the weight measurement.

Our W_r results in Upper Penitencia Creek are comparable to other populations of juvenile *O. mykiss* from Alaska through northern California. McLaughlin (2009) calculated the average W_r for over 100 juvenile *O. mykiss* populations of various size throughout northern California, Oregon, Washington, and Alaska. Average W_r for populations in McLaughlin's dataset ranged from 78.2 to 118.1 with an average of 97.7. The 2020 sampled population in Upper Penitencia Creek had an average W_r of 100.2, and thus falls within the aforementioned range, though slightly above the overall average.

In comparison to 2019 sampling in Upper Penitencia Creek, juvenile *O. mykiss* sampled in 2020 had a lower mean W_r that was statistically significant. This difference can be due to factors such as changes in environmental variables or the sampling period occurring earlier in the season (August versus November). In 2020, operational changes to Cherry Flat Reservoir were implemented by the City of San Jose, and the entire County also experienced a relatively poor water year. These conditions created lower flow conditions and may have impacted both the abundance and condition of juvenile *O. mykiss.* The large discrepancy in sample size between years (88 individuals in 2019 versus 9 individuals in 2020) should likewise be considered when interpreting this result. Juvenile *O. mykiss* in both sampling years were still in healthy condition despite any significant differences, with mean population relative weights equaling or exceeding 100. Interannnual trends are difficult to assess at this time due to the limited timeframe over which data has been collected, the difference in seasonality of the sampling periods, and the small sample size in the second year, but more conclusive comparisons will become possible as more data is collected.

With continued *O. mykiss* juvenile rearing sampling in the system, additional climatic variation (e.g., dry, warm years vs. wet, cold years) and flow conditions can be incorporated into the results to determine if there is any correlation between these factors and fish condition. By using W_r as a condition index, we were able to make direct comparisons among fish of different lengths and between years, and thus summarize the overall health of juvenile *O. mykiss* in Upper Penitencia Creek. The W_r approach also provides opportunities for comparisons to be made between this system and other *O. mykiss* populations in Santa Clara County in the future.

Juvenile *O. mykiss* sampled in Upper Penitencia Creek in 2020 were overall in healthy condition, indicating that environmental conditions within the system are favorable for supporting the growth of juvenile *O. mykiss* and maintaining an *O. mykiss* population in good condition.

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Appendix A

Individual Measurements, Standard Weights (W_s), and Relative Weights (W_r) of *O. mykiss* Sampled During Summer 2020 Upper Penitencia Creek Juvenile Rearing Monitoring

FishID	Weight (g)	Fork-Length (mm)	W_s (g)	W_r (%)	Site
2020UPC001B*	–	123	21.34235	–	UP005
2020UPC002B*	–	104	13.05791	–	UP005
2020UPC003B*	–	183	68.30568	–	UP003
2020UPC004B*	–	144	33.85988	–	UP003
2020UPCA001	36.1	151	38.9085	92.78178	UP006
2020UPCA002	31.5	142	32.50127	96.9193	UP006
2020UPCA003**	124	237	–	–	UP006
2020UPCA004	59.1	178	62.98393	93.83346	UP006
2020UPCA005	39.3	152	39.66779	99.07282	UP006
2020UPCA006	79.4	196	83.50756	95.08122	UP006
2020UPCA007**	172.8	248	–	–	UP004
2020UPCA008	38.2	147	35.96708	106.2082	UP004
2020UPCA009	25.4	129	24.53616	103.5207	UP004
2020UPCA010	22.2	121	20.34209	109.1333	UP004
2020UPCA011	26.4	130	25.09725	105.1908	UP004

* Four individuals sampled from Upper Penitencia Creek were not weighed and relative weight could not be calculated.

**The standard weight equation used in the analysis applies to juvenile *O. mykiss* between 50-200 mm fork-length; therefore, individuals with fork-lengths >200 mm were excluded.

Coyote Creek Watershed *Oncorhynchus mykiss* 2019 – 2020 Migration Monitoring Using Passive Integrated Transponder Tags

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Contents

Tables

Figures

Appendices

1. Introduction

The Coyote Creek Watershed is the largest watershed in Santa Clara County, encompassing over 829 square kilometers. The eastern and southern portions of the watershed drain most of the western face of the Diablo Mountain Range where the headwaters originate at elevations up to 1,110 meters. These upper watershed areas remain undeveloped with little anthropogenic disturbance. The northern and western portions of the watershed are comprised of the Santa Clara County valley floor. Portions of the valley floor are extensively urbanized with patches of undeveloped parks and open agricultural lands. Coyote Creek has 29 tributaries and flows northwest through the valley, approximately 68 kilometers from the headwaters, where it enters the southern extent of the San Francisco Bay. The Coyote Creek Watershed supports the Central California Coast steelhead (*Oncorhynchus mykiss*) distinct population segment, which is a federally threatened species. Two systems in the Coyote Creek Watershed contain *O. mykiss* and are defined as critical habitat: Coyote Creek (below Anderson Dam) and Upper Penitencia Creek. Critical habitat for *O. mykiss* in Coyote Creek extends from the creek's confluence with the San Francisco Bay to the base of the Leroy Anderson Dam. Critical Habitat for Upper Penitencia Creek extends from the creek's confluence with Coyote Creek to the base of the dam at Cherry Flat Reservoir. Though critical habitat extends to the base of the dam at Cherry Flat Reservoir, natural barriers (Alum Rock Falls) likely precludes steelhead from reaching the most upstream critical habitat.

In Fall 2019, Valley Water conducted the first year of juvenile *O. mykiss* sampling at 10 stations in the Coyote Creek Watershed to determine the presence of *O. mykiss* as well as the composition of other fish species. Ninety-nine, appropriately sized *O. mykiss* were tagged with half-duplex (HDX) passive integrated transponder (PIT) tags to study their movement within the Coyote Creek Watershed.

A PIT tag is a small passive transponder that contains a unique 15-digit number, which allows researchers to tag fish with distinct codes. An HDX radio-frequency identification (RFID) reader generates short magnetic pulses that wirelessly charge a capacitor inside a PIT tag. When the charge field turns off, the tag uses the stored power to send the tag number back to the reader without interference from the reader (Oregon RFID 2019). In addition to relaying the tag number, information on date and time is recorded when a tag is detected in the proximity of the system. The distance to which a tag can be detected from the antenna is variable based on the antenna read range. Many factors contribute to the read range of passive tags including operation frequency, antenna power, tag orientation, and interference from other devices (Biomark 2020). In the Coyote Creek Watershed, two stationary tag reading systems were deployed: one on the Coyote Creek mainstem, and one on Upper Penitencia Creek.

The goal of this study was to gain a better understanding of juvenile *O. mykiss* migratory timing and behavior in the Coyote Creek Watershed. Additionally, this study was aimed at revealing what proportion of the tagged population showed migratory tendencies and from which sub-watershed.

2. Methods

2.1 Fish PIT Tagging

O. mykiss in the Coyote Watershed were PIT tagged at six stations on Coyote Creek and four stations on Upper Penitencia Creek (Figure 1) during the Valley Water 2019 juvenile rearing monitoring conducted in November of 2019 (Valley Water 2020). Multi-pass depletion backpack electrofishing was conducted at each station to determine the presence of *O. mykiss* as well as the composition of other fish species in the Coyote Creek Watershed. *O. mykiss* with a fork-length greater than or equal to 65 mm, but less than 150 mm, received a 12 mm HDX PIT tag. *O. mykiss* with a fork-length of 150 mm or greater received a 23 mm HDX PIT tag (Figure 2). Twenty-two of the fish captured and tagged in the Coyote Creek Watershed received a 23 mm tag. The remaining 77 received a 12 mm tag. PIT tag numbers and associated biological data for all fish tagged by Valley Water in Santa Clara County are included in Appendix A. All PIT tagging was conducted in accordance with the PIT Tag Marking Procedures Manual (CBFWA 1999) by staff trained in the procedure.

A total of 99 *O. mykiss* were tagged in the Coyote Creek Watershed in 2019: three on Coyote Creek and 96 on Upper Penitencia Creek. While sampling occurred at six locations on Coyote Creek, *O. mykiss* were only captured at one location (COY004). Fish were tagged at two of the four sampling stations on Upper Penitencia Creek (UP003 and UP004) and one bonus site that was sampled to increase the number of PIT tagged fish in the system (Santa Clara Valley Water, 2020). Tagging locations are displayed in Figure 1.

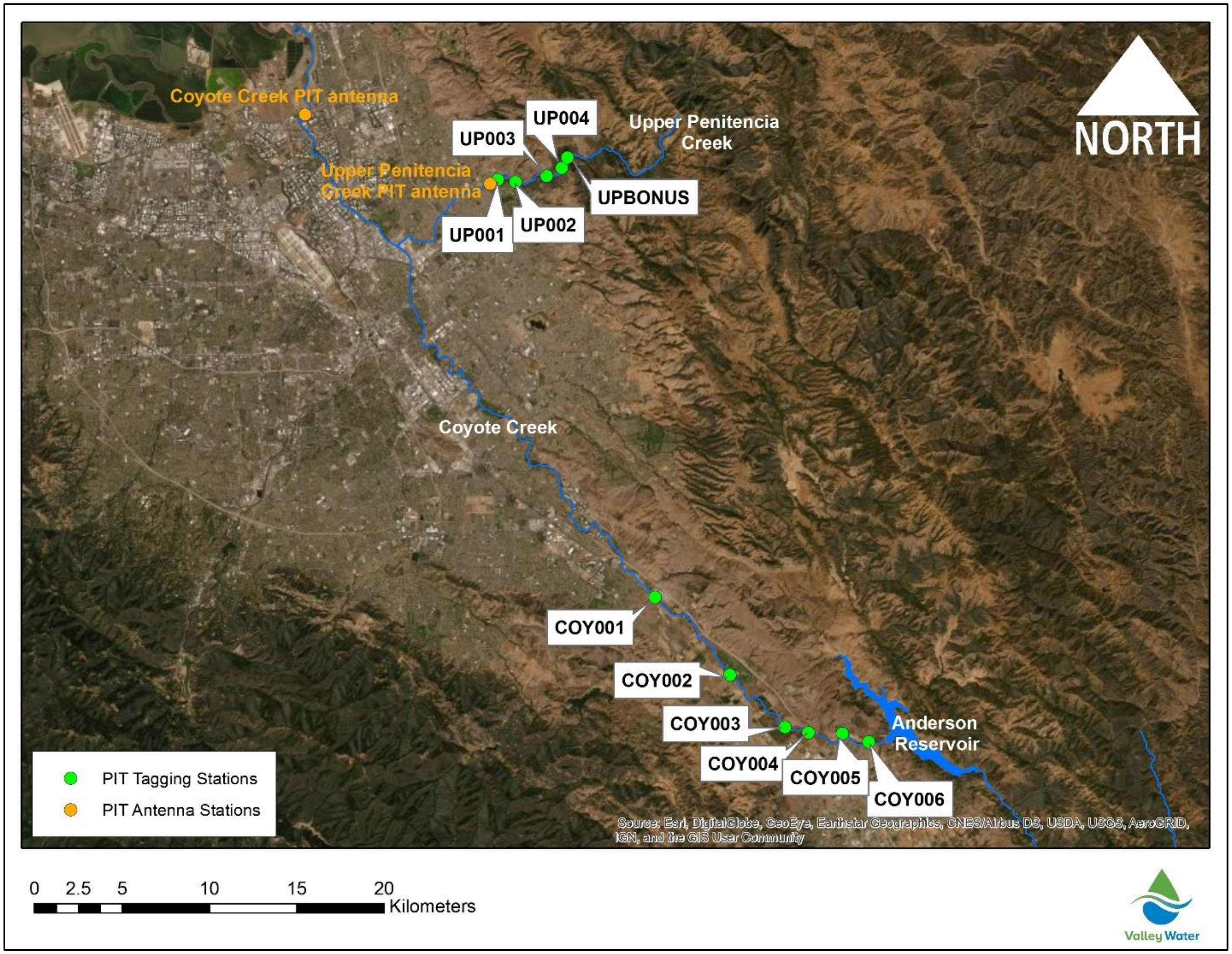

Figure 1. PIT tag antennas and tagging sites for Coyote Creek and Upper Penitencia Creek. Juveniles were tagged at COY004, UP003, and UP004.

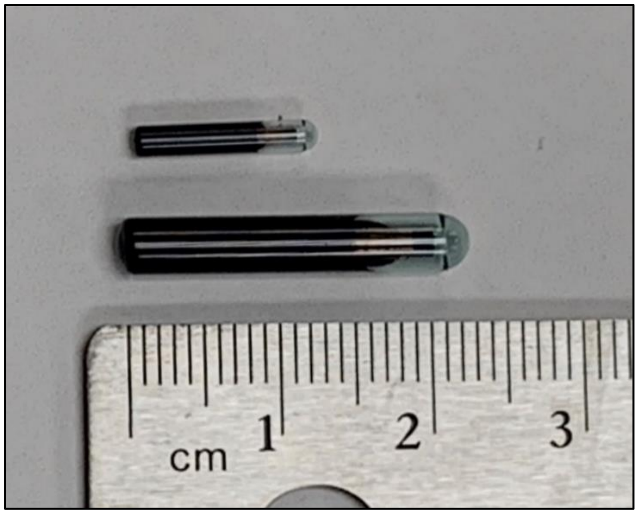

Figure 2. 12 mm (top) and 23 mm (bottom) HDX PIT tags.

2.2 Antenna Construction and Operation

The two antennas installed in the Coyote Creek Watershed used HDX RFID technology. The basic components of the HDX arrays consisted of an RFID reader, a power source, a tuning capacitor, and an antenna. When readers detect a PIT tag, they store the following detection data: PIT tag number, date and time stamp, , and number of scans since last detection. The antenna was programmed to scan for tags 10 times per second.

Detections recorded by the antennas installed in the Coyote Watershed indicate proximity to the antenna at a given time but do not indicate direction of movement. Assumptions must be made about direction based on the fish release point after tagging occurs and the position of the antenna in the watershed. Assumptions are also made that detections are of the target species, and not tags that have been expelled and are mobile in the system or are in the digestive system of a predatory species. Details on each antenna installed in the Coyote Watershed are provided below.

Upper Penitencia Creek Antenna

An antenna was installed on Upper Penitencia Creek for the first time on October 24, 2019. It was located just below the perennial reaches of Upper Penitencia Creek. This antenna is a 10.8 m long by 0.67 m high swim-through design, using a static line affixed to a tree on one bank and a T-post on the other bank as the top support and metal stakes in the substrate to maintain contact with the bottom of the channel (Figure 3). The antenna uses a single loop of 10 AWG copper wire. The braided wire between the antenna and tuning box is 4.8 m in length. The twinax cable connecting the tuning box to the reader is 18.7 m in length. The antenna wire was connected to the static line and stakes in the bottom of the channel with plastic zip-ties. Care was taken to avoid direct contact between the metal stakes, T-post, and the antenna wire. The antenna was initially powered by two 12-volt batteries, but on December 2, 2019 the antenna was connected to direct AC power. From this point on, the antenna was powered by a 120-volt wired receptacle and connected to a 12-volt power inverter.

The antenna provided complete lateral coverage of the channel during most flows, but when the floodplain inundated during large storm events, areas along the channel margin did not receive coverage. Additionally, two antenna outages occurred during the period of operation (Table 1).The read range consistently spanned the entire height of the antenna between the top and bottom wires for the 23 mm tags. The 12 mm tag had an average read range of 26 cm, which created a 15 cm dead zone in the middle of the antenna. The read range up- and downstream of the antenna was typically 7 cm and 22 cm for the 12 mm and the 23 mm tag, respectively. The antenna was removed on May 23, 2020.

Figure 3. Swim-through antenna on Upper Penitencia Creek, photographed when stream was dry. Arrow indicates top wire in the loop.

Table 1. Upper Penitencia antenna recorded outage duration and type during the monitoring period.

Site	Reader	Outage Type	Outage Start	Outage End
Noble Diversion	UPC1	Complete	11/1/2019 UNK	11/5/2019 UNK
Noble Diversion	UPC1	Complete	4/17/2020 14:19	05/06/202 14:12
*Date and time of outage is often unknown as log files do not record all potential outage types.				

Lower Coyote Creek Antenna - Coyote Creek

The Coyote Creek antenna was installed on January 30, 2020 within the city limits of Milpitas in the lower reaches of Coyote Creek. This antenna is located downstream of Upper Penitencia Creek, which provides the ability to detect outmigrants from the Upper Penitencia sub-watershed. The antenna was constructed with two loops of 10 American Wire Gauge (AWG) enclosed and separated by two 1.9 cm PVC pipes. It measured 6.7 m wide by 0.6 m high and was constructed in a swim-through design (Figure 4). The antenna was secured with red head concrete anchors driven into the banks and along the channel bottom. Additional plastic zip-ties and bolts were used to secure the lower portion of the antenna to the substrate and sandbags were placed along the antenna to secure it further. A stainless-steel cable was stretched across the channel and anchored to either bank and attached to the top of the PVC pipes with hose clamps and plastic zip-ties to hold the shape of the top of the antenna during high flows. The tuner was buried in the bank and covered with riprap approximately four feet from the antenna (Jack Eschenroeder, FISHBIO). The antenna was powered by two pole-mounted 300-watt solar panels and a Victron Energy charge controller connected to four 6-volt batteries. The distance between the reader and the tuner was approximately 70 feet (Jack Eschenroeder, FISHBIO). FISHBIO was contracted by Valley Water to install and maintain the Coyote Creek antenna.

Figure 4. Coyote Creek swim-through antenna design. Installed on the lower portion of Coyote Creek.

The antenna provided nearly 100% coverage of the channel under base flow conditions. There was a distance of one-to-two feet on either side of the antenna and the respective bank that was not covered, but this area was shallow and largely blocked by boulders and rocks. During periods of high flow this area would have enlarged to create a considerable gap around either side of the antenna. There were no outages between February 13th and June 19th (Figure 5); however, in periods of higher flow it is anticipated that antenna efficiency decreased (Pers. Comms. FISHBIO staff). The read range for 12 mm PIT tags directly above the antenna was approximately 30 cm and 46 cm upstream and downstream of the antenna, respectively. An exact read range for 23 mm PIT tags was not recorded, but it was estimated that 23 mm tags were detected up to 61 cm both upstream and downstream of the antenna once it was fully operational (Jim Inman, FISHBIO). While the antenna was installed on January 30, it was not operating reliably until February 13, 2020 due to power supply and tuning board issues (Table 2). After February 13, 2020 the antenna did not experience any outages and appeared to be operational until its removal on June 19, 2020.

Table 2. Coyote Creek antenna recorded outage duration and type during the monitoring period. Information from antenna coverage file provided by FISHBIO.

Site	Reader	Outage Type	Outage Start	Outage End
Coyote Creek	Coyote1	Complete	1/30/2020 0:00	2/13/2020 13:00
*Date and time of outage is often unknown as log files do not record all potential outage types.				

3. Results and Discussion

This monitoring report is for the 2019-2020 *O. mykiss* migration season. Therefore, the results presented below contain data collected from October 1, 2019 to May 31, 2020.

3.1 Upper Penitenica Creek Antenna

O. mykiss were tagged at three locations on Upper Penitencia Creek, all of which were upstream of the antenna (UP003, UP004, and UPBONUS; Figure 1). The Upper Penitencia Creek antenna is located 7 km upstream of the confluence with Coyote Creek. Assumptions on movement of these in this first year indicate all downstream movement as downstream portions of Upper Penitencia Creek experience intermittent flows during summer and fall months and fish would not have been able to move downstream prior to the installation of the antenna. Determining if outmigration occurred all the way to Coyote Creek cannot be confirmed unless they were subsequently detected by the antenna on Coyote Creek. A total of four individual PIT tags implanted in *O. mykiss* were detected at this station (Table 4). All of the tags detected were 23 mm tags from fish tagged in the Upper Penitencia Creek sub-watershed. Of the four fish detected, only *O. mykiss* #6096 (last four digits of PIT tag identification number) was detected on more than one day (4/13/20 and 4/15/20). The two detections of *O. mykiss* #6069 occurred within two days of one another. The three other *O. mykiss* detected on single days were likely displaying migratory tendencies. Relative paths of detected *O.*

mykiss from their tagging locations to the Upper Penitencia Creek antenna are shown in Figure 5.

Movement of *O. mykiss* at the Upper Penitencia Creek antenna was associated with flow events during the 2020 migration season. Fish often moved on the ascending limb of the hydrograph during storm events, but one fish (#6096) moved as flows were returning to baseline (Figure 6). All detections occurred at flows under 5 cfs. It is assumed these fish were displaying outmigrant tendencies but as the antenna does not provide directional information, it is difficult to conclude *O. mykiss* direction of movement.

While the detections at the Upper Penitencia Creek antenna indicate outmigrant tendencies none of the tags were subsequently detected at the Lower Coyote Creek antenna. There were no outages recorded at the antenna during the month of movement for the fish tagged at Upper Penitencia Creek but the Coyote Creek antenna did not provide complete lateral coverage during high flow events so detection could have been avoided. Flows in Upper Penitencia Creek provided a very limit passage window to allow for migration to Coyote Creek (Smith 2020). While outmigration and movement into Coyote Creek is assumed it cannot be confirmed, and passage conditions were limited in the 2019-2020 migration season.

Table 3. Tag detections of *O. mykiss* at the Upper Penitencia PIT array. Tags detected on multiple days were recorded as the last day detected in this table. No tags detected from tagging site UP003.

Date Tagged	Date Detected	Tag ID	Creek	Tagging Station	Fork-length (mm)
11/4/2019	4/15/2020	982_126058146096	Upper Penitencia Creek	UP004	172
11/4/2019	4/5/2020	900_228000613727	Upper Penitencia Creek	UP004	158
11/13/2019	4/5/2020	900_228000613736	Upper Penitencia Creek	UPBONUS	168
11/4/2019	3/15/2020	900_228000613731	Upper Penitencia Creek	UP004	172

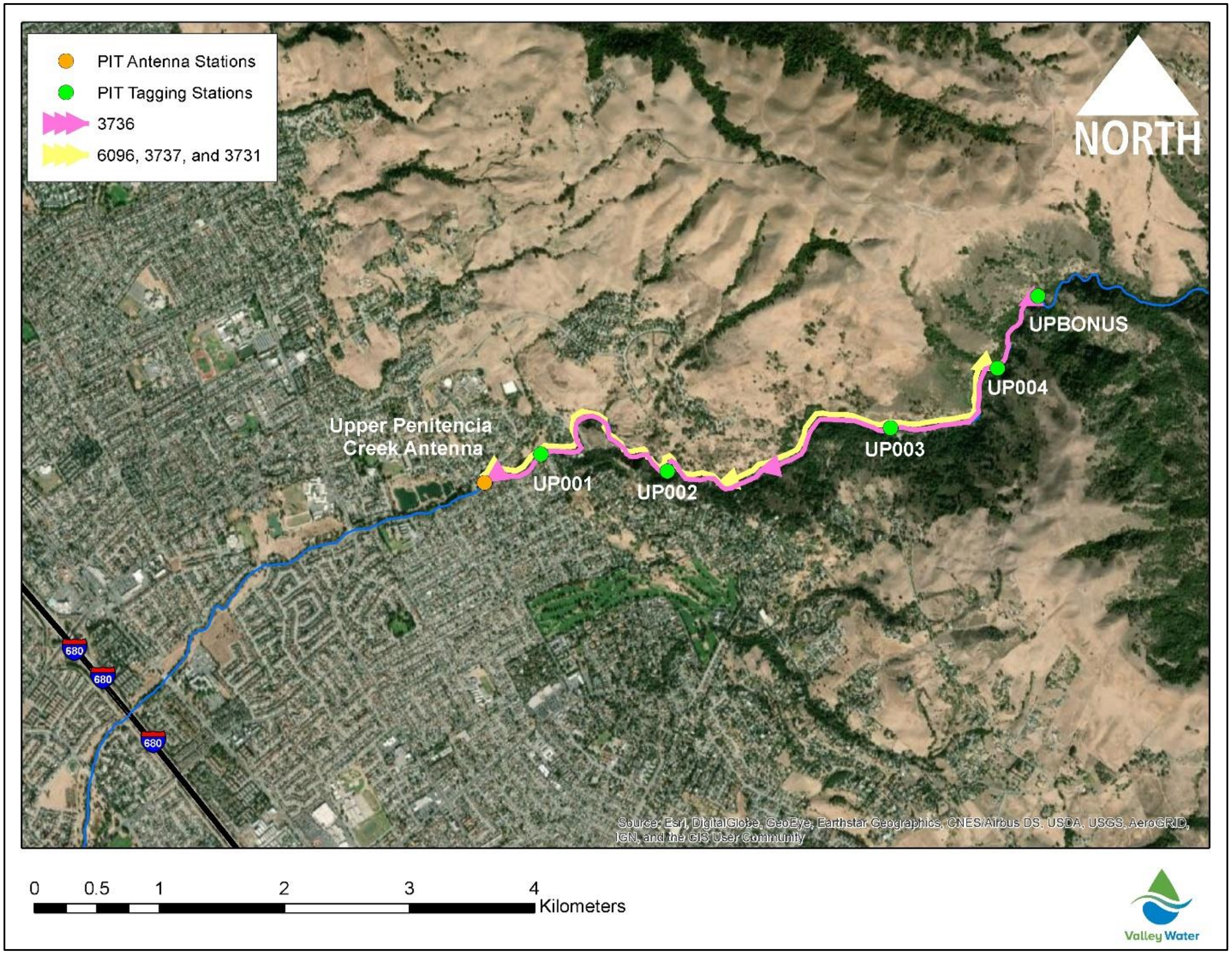

Figure 5. *O. mykiss* tagging locations and relative path to the Upper Penitencia Creek antenna. Nested arrows in legend indicate the relative paths of individual PIT tags, identified by the last four digits of their implanted PIT tag cod

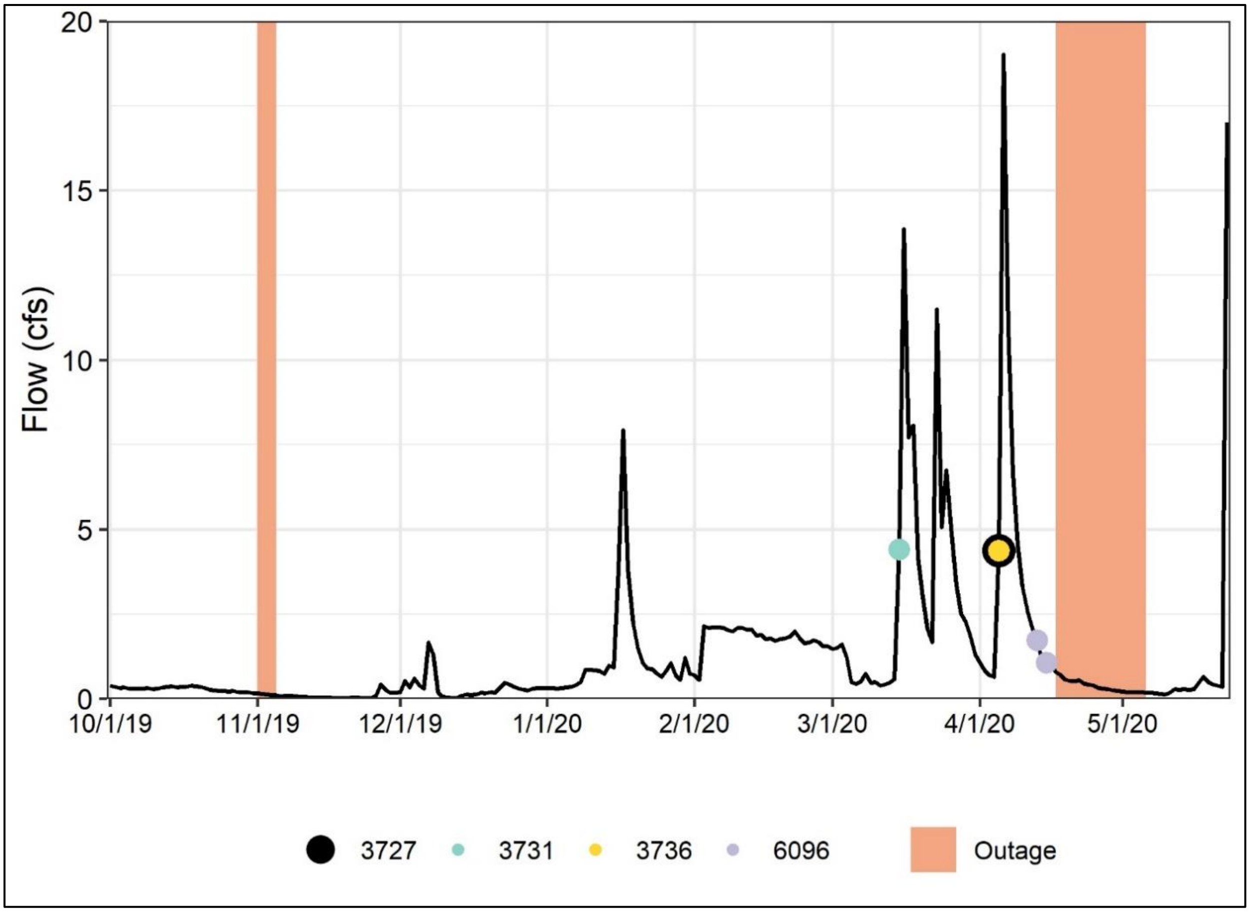

Figure 6. *O. mykiss* tracked at the Upper Penitencia antenna compared to average daily flow on Upper Penitencia Creek at Dorel Drive stream gage (ALERT 5083) and periods of antenna outage. Numbers in legend indicate the last four digits of PIT tag numbers.

The *O. mykiss* detected in Upper Penitencia Creek ranged from 158 to 172 mm in fork-length when tagged. These lengths were recorded up to five months prior to the detection date, so the fish were likely larger than when tagged.

Growth rates of juvenile *O. mykiss* in California are highly variable and are dependent on temperature, food availability, seasonal flow, and population densities/competition (Moyle 2002). According to Moyle (2002), in small streams with low summer flows, such as Upper Penitencia Creek, young-of-the-year steelhead measure 50–90 mm, and fish at the end of their second year measure 100–160 mm. Smith (2018) aged fish from Upper Penitencia Creek between 2011 and 2018 and found that young-of-the-year *O. mykiss* ranged from 80–144 mm, while fish in their second year ranged from 85–229 mm, and fish in their third year 205-359 mm. This is a faster growth rate than predicted by Moyle (2002). Based on Moyle's (2002) growth rates, *O. mykiss* tracked at the Upper Penitencia Creek antenna were most likely in their second year when tagged. Based on Smith's (2018) growth rates, *O. mykiss* detected at the Upper Penitencia Creek antenna were also likely at the end of their second year. Without otolith or scale analysis the ages cannot be confirmed.

3.2 Lower Coyote Creek Antenna – Coyote Creek

O. mykiss were tagged at one sampling location on Coyote Creek in November 2019. The Coyote Creek antenna was located low in the system, downstream of Upper Penitencia Creek. None of the fish tagged in the Coyote Creek Watershed were detected at the Coyote Creek antenna, including fish tagged on Upper Penitencia Creek. Two periods of high flow >300cfs, occurred in late March and early April when fish migrating out of the system could have avoided detection (Figure 7).

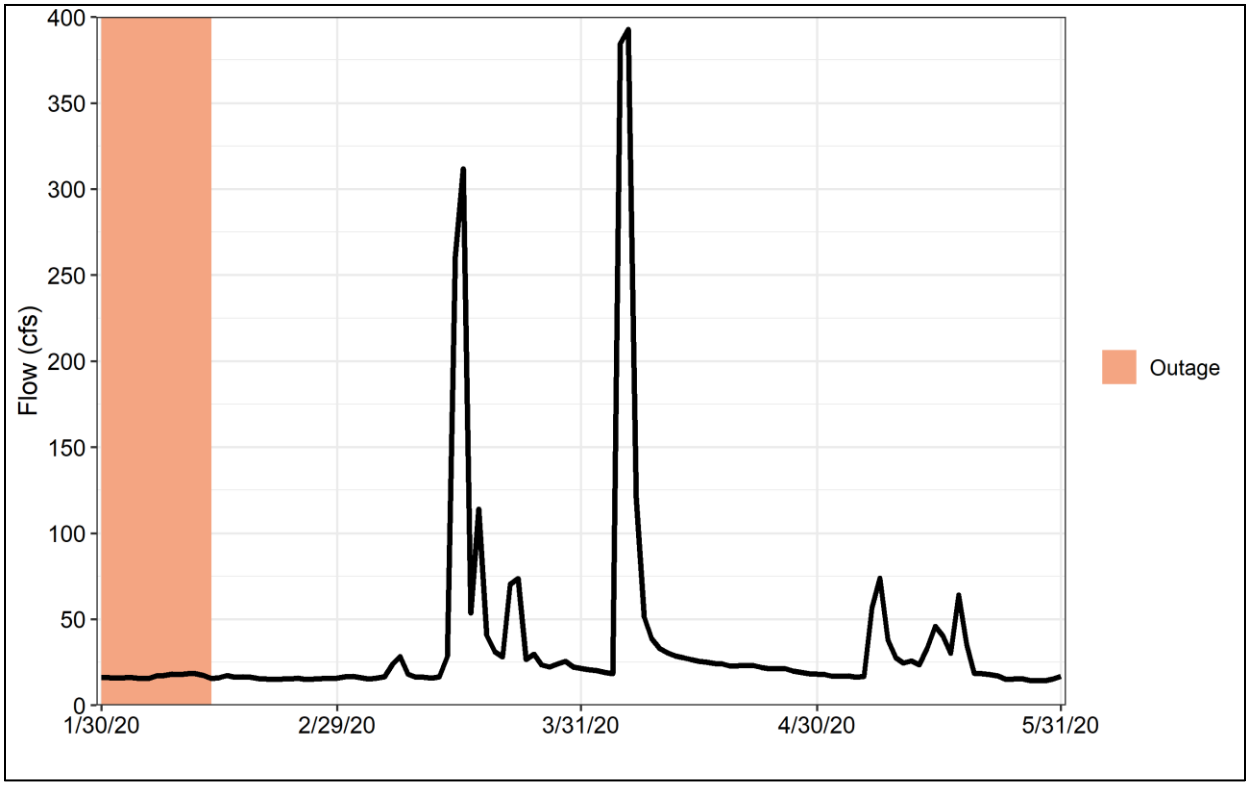

Figure 7. Daily average flow (cfs) on Coyote Creek at Highway 237 USGS gage and periods of antenna outage. Antenna was not functioning from date of install 1/30/2020 to 2/13/2020.

4. Conclusion

O. mykiss showing migratory tendencies were recorded from March through April in the Upper Penitencia Creek sub-watershed. Successful outmigration or movement between sub-watersheds cannot be concluded as no tags were detected at the Lower Coyote Creek antenna on Coyote Creek. Coyote Creek had a lower number of tagged fish (n=3) than Upper Penitencia, and a period without antenna coverage from January to mid-February, which could be contributing to the lack of detections at downstream Coyote Creek. Additionally, the Lower Coyote Creek antenna did not provide full lateral coverage of the channel during high flows and two such events occurred during the period of operation. These two flow events also coincided with detections of fish at the Upper Penitencia antenna. As part of a status review for West Coast steelhead, Busby et al. (1996) analyzed scale and otolith data from adult *O. mykiss* and found that the modal smolt age for *O. mykiss* in Washington, Oregon, and California was typically two years. However, the most southern portion of the *O. mykiss* range had an increase in frequency of 1-year-old *O. mykiss* smolts compared with the northern portion. Based on this data, the *O. mykiss* tracked by the Upper Penitencia Creek antenna generally fall in line with what is typically expected of this population.

As this effort represented the first season of PIT tag monitoring in the Coyote Creek Watershed, results are limited and comparisons to previous years cannot yet be made. Valuable lessons were learned regarding the placement, design, and implementation of PIT tag arrays in the Coyote Creek Watershed. Once additional PIT tagging is conducted in the system and more antennas are installed, a more robust dataset and the ability to tease out directionality will develop over time.

5. References

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Appendix A

PIT Tag Master List

Tag Date	Creek	Weight (g)	Fork Length (mm)	PIT ID
9/17/2018	Alamitos Creek		199	900.226000319320
9/17/2018	Alamitos Creek	23.03	122	900.226000319348
9/17/2018	Alamitos Creek	13.3	102	900.226000319339
9/17/2018	Alamitos Creek	15.09	107	900.226000319313
9/17/2018	Alamitos Creek	8.33	89	900.226000319367
9/17/2018	Alamitos Creek		248	900.226000319355
9/17/2018	Alamitos Creek	12.92	103	900.226000319350
9/17/2018	Alamitos Creek	21.42	119	900.226000319366
9/17/2018	Alamitos Creek	19.34	117	900.226000319375
9/17/2018	Alamitos Creek	16.51	111	900.226000319326
9/17/2018	Alamitos Creek	23.78	122	900.226000319387
9/17/2018	Alamitos Creek	26.74	132	900.226000319376
9/17/2018	Alamitos Creek	30.42	141	900.226000319319
9/17/2018	Alamitos Creek	32.1	136	900.226000319352
9/17/2018	Alamitos Creek	13.3	103	900.226000319314
9/17/2018	Alamitos Creek	15.14	111	900.226000319353
9/17/2018	Alamitos Creek	11.5	97	900.226000319372
9/17/2018	Alamitos Creek	14.39	104	900.226000319316
9/17/2018	Alamitos Creek	14.48	106	900.226000319360
9/17/2018	Alamitos Creek	43.06	146	900.226000319370
9/17/2018	Alamitos Creek	32.7	138	900.226000319391
9/17/2018	Alamitos Creek	25.26	129	900.226000319310
9/17/2018	Alamitos Creek	81.27	186	900.226000319301
9/17/2018	Alamitos Creek	19.01	117	900.226000319384
9/17/2018	Alamitos Creek	11.97	102	900.226000319397
9/17/2018	Alamitos Creek	10	95	900.226000319388
9/17/2018	Alamitos Creek	18.58	115	900.226000319321
9/17/2018	Alamitos Creek	17.2	109	900.226000319322
10/16/2018	Guadalupe Creek	6.93	86	900.226000319364
10/16/2018	Guadalupe Creek	8.33	84	900.226000319358
10/16/2018	Guadalupe Creek	4.58	66	900.226000319338
10/16/2018	Guadalupe Creek	6.82	81	900.226000319385
10/16/2018	Guadalupe Creek	31.33	138	900.226000319389
10/16/2018	Guadalupe Creek	3.58	65	900.226000319308
10/16/2018	Guadalupe Creek	3.72	66	900.226000319334
10/16/2018	Guadalupe Creek	4.62	72	900.226000319305
10/16/2018	Guadalupe Creek	6.37	72	900.226000319341
10/16/2018	Guadalupe Creek	14.28	106	900.226000319293
10/16/2018	Guadalupe Creek	9.25	87	900.226000319276
10/16/2018	Guadalupe Creek	7.81	83	900.226000319227
10/16/2018	Guadalupe Creek	4.75	67	900.226000319318
10/16/2018	Guadalupe Creek	4.97	70	900.226000319351
10/16/2018	Guadalupe Creek	6.12	76	900.226000319329
10/16/2018	Guadalupe Creek	6.66	79	900.226000319345
10/16/2018	Guadalupe Creek	5.32	74	900.226000319324
10/17/2018	Guadalupe Creek	8.05	86	900.226000319344

10/17/2018	Guadalupe Creek	4.23	68	900.226000319330
10/17/2018	Guadalupe Creek	5.31	74	900.226000319398
10/17/2018	Guadalupe Creek	11.22	90	900.226000319304
10/17/2018	Guadalupe Creek	5.23	74	900.226000319362
10/17/2018	Guadalupe Creek	5.05	79	900.226000319327
10/17/2018	Guadalupe Creek	3.85	68	900.226000319393
10/17/2018	Guadalupe Creek	18.15	112	900.226000319328
10/17/2018	Guadalupe Creek	4.53	67	900.226000319354
10/17/2018	Guadalupe Creek	4.36	69	900.226000319379
10/17/2018	Guadalupe Creek	6.22	79	900.226000319374
10/17/2018	Guadalupe Creek	4.95	69	900.226000319356
10/17/2018	Guadalupe Creek	4.95	69	900.226000319325
10/17/2018	Guadalupe Creek	6.23	75	900.226000319395
10/17/2018	Guadalupe Creek	5.68	72	900.226000319371
10/17/2018	Guadalupe Creek	4.63	70	900.226000319377
10/17/2018	Guadalupe Creek	4.35	66	900.226000319399
10/17/2018	Guadalupe Creek	6.62	76	900.226000319342
10/17/2018	Guadalupe Creek	6.06	75	900.226000319307
10/17/2018	Guadalupe Creek	3.83	65	900.226000319333
10/17/2018	Guadalupe Creek	5.66	74	900.226000319361
10/17/2018	Guadalupe Creek	96.04	199	900.228000613702
10/17/2018	Guadalupe Creek	4.61	65	900.226000319381
10/17/2018	Guadalupe Creek	5.62	75	900.226000319346
10/17/2018	Guadalupe Creek	4.22	66	900.226000319394
10/17/2018	Guadalupe Creek	6.02	79	900.226000319386
10/17/2018	Guadalupe Creek	5.9	77	900.226000319340
10/17/2018	Guadalupe Creek	4.52	70	900.226000319317
10/17/2018	Guadalupe Creek	5.14	72	900.226000319337
10/17/2018	Guadalupe Creek	4.08	67	900.226000319309
10/18/2018	Alamitos Creek	3.25	65	900.226000319292
10/18/2018	Alamitos Creek	4.86	69	900.226000319295
10/18/2018	Alamitos Creek	20.6	125	900.226000319250
10/18/2018	Alamitos Creek	42.3	146	900.226000319257
10/18/2018	Alamitos Creek	16.8	110	900.226000319290
10/18/2018	Alamitos Creek	18.6	106	900.226000319269
10/18/2018	Alamitos Creek	4.23	66	900.226000319260
10/18/2018	Alamitos Creek	20.2	111	900.226000319200
10/18/2018	Alamitos Creek	17.5	109	900.226000319246
10/18/2018	Alamitos Creek	36.5	145	900.226000319258
10/18/2018	Alamitos Creek	14.8	79	900.226000319263
10/18/2018	Alamitos Creek	24.9	109	900.226000319201
10/18/2018	Alamitos Creek	12.5	94	900.226000319218
10/18/2018	Alamitos Creek	19	108	900.226000319311
10/18/2018	Alamitos Creek	5.35	68	900.226000319284
10/18/2018	Alamitos Creek	4.35	65	900.226000319291
10/22/2018	Alamitos Creek	10.2	90	900.226000319390
10/22/2018	Alamitos Creek	9.4	92	900.226000319363

10/22/2018	Alamitos Creek	445	345	900.228000613703
10/22/2018	Alamitos Creek	10	91	900.226000319365
10/22/2018	Alamitos Creek	12.8	103	900.226000319382
10/22/2018	Alamitos Creek	14.1	102	900.226000319315
10/22/2018	Alamitos Creek	9.6	91	900.226000319312
10/22/2018	Alamitos Creek	13	100	900.226000319349
10/22/2018	Alamitos Creek	13.8	98	900.226000319306
10/22/2018	Alamitos Creek	7.7	84	900.226000319343
10/22/2018	Alamitos Creek	28.2	129	900.226000319380
10/22/2018	Alamitos Creek	20.8	117	900.226000319368
10/22/2018	Alamitos Creek	23	119	900.226000319378
10/22/2018	Alamitos Creek	25.1	115	900.226000319396
10/23/2018	Calero Creek	125.2	216	900.228000613705
10/23/2018	Calero Creek	215.3	263	900.228000613704
10/23/2018	Calero Creek	7.3	82	900.226000319302
10/23/2018	Calero Creek	10.1	89	900.226000319332
10/23/2018	Calero Creek	5.2	67	900.226000319373
10/23/2018	Calero Creek	7.5	82	900.226000319280
10/23/2018	Calero Creek	14.3	109	900.226000319268
10/23/2018	Calero Creek	11.5	95	900.226000319336
10/24/2018	Calero Creek	9.3	84	900.226000319357
10/24/2018	Calero Creek	12.5	94	900.226000319244
10/24/2018	Calero Creek	8.5	85	900.226000319231
10/24/2018	Calero Creek	10.4	86	900.226000319300
10/24/2018	Calero Creek	5.4	75	900.226000319323
10/24/2018	Calero Creek	7.8	84	900.226000319347
10/24/2018	Calero Creek	10.2	93	900.226000319230
10/24/2018	Calero Creek	9.4	86	900.226000319212
10/24/2018	Calero Creek	8.3	82	900.226000319287
11/6/2018	Guadalupe Creek	18.2	116	900.226000319278
11/6/2018	Guadalupe Creek	12.4	95	900.226000319294
11/6/2018	Guadalupe Creek	8.7	87	900.226000319214
10/9/2019	Guadalupe Creek	8.6	84	900.226000319228
10/9/2019	Guadalupe Creek	14.7	104	900.226000319222
10/9/2019	Guadalupe Creek	5.1	71	900.226000319209
10/9/2019	Guadalupe Creek	53.6	168	900.228000613712
10/9/2019	Guadalupe Creek	9.6	85	900.226000319220
10/9/2019	Guadalupe Creek	8	76	900.226000319237
10/9/2019	Guadalupe Creek	152.1	234	900.228000613711
10/9/2019	Guadalupe Creek	7.1	81	900.226000319210
10/9/2019	Guadalupe Creek	9.5	88	900.226000319239
10/9/2019	Guadalupe Creek	6.6	84	900.226000319233
10/9/2019	Guadalupe Creek	5.73	75	900.228000613710
10/9/2019	Guadalupe Creek	5.8	77	900.226000319277
10/10/2019	Guadalupe Creek	13.4	104	900.226000319247
10/10/2019	Guadalupe Creek	16.5	107	900.226000319272
10/10/2019	Guadalupe Creek	10.4	91	900.226000319281

10/10/2019	Guadalupe Creek	9.5	89	900.226000319216
10/10/2019	Guadalupe Creek	7.7	81	900.226000319219
10/10/2019	Guadalupe Creek	10.2	91	900.226000319242
10/10/2019	Guadalupe Creek	7.1	81	900.226000319206
10/10/2019	Guadalupe Creek	14.3	99	900.226000319261
10/10/2019	Guadalupe Creek	6.5	82	900.226000319296
10/10/2019	Guadalupe Creek	16.3	106	900.226000319204
10/10/2019	Guadalupe Creek	41.7	150	900.226000319215
10/10/2019	Guadalupe Creek	7.9	85	900.226000319249
10/10/2019	Guadalupe Creek	3.4	66	900.226000319369
10/10/2019	Guadalupe Creek	9.4	89	900.226000319252
10/10/2019	Guadalupe Creek	8.6	86	900.226000319208
10/10/2019	Guadalupe Creek	8.6	82	900.226000319288
10/10/2019	Guadalupe Creek	12.3	100	900.226000319217
10/23/2019	Alamitos Creek	7.9	83	900.226000319254
10/23/2019	Alamitos Creek	15.1	106	900.226000319256
10/23/2019	Alamitos Creek	9	88	900.226000319211
10/23/2019	Alamitos Creek	11.4	95	900.226000319265
10/23/2019	Alamitos Creek	10.7	90	900.226000319273
10/23/2019	Alamitos Creek	22.9	122	900.226000319274
10/23/2019	Alamitos Creek	4.7	67	900.226000319240
10/23/2019	Alamitos Creek	14.4	105	900.226000319236
10/23/2019	Alamitos Creek	4.8	69	900.226000319223
10/23/2019	Alamitos Creek	11.5	87	900.226000319203
10/23/2019	Alamitos Creek	5.5	75	900.226000319205
10/23/2019	Alamitos Creek	3.3	65	900.226000319225
10/23/2019	Alamitos Creek	3.9	68	900.226000319282
10/23/2019	Alamitos Creek	4.9	71	900.226000319224
10/23/2019	Alamitos Creek	5.7	76	900.226000319248
10/23/2019	Alamitos Creek	13.9	105	900.226000319221
10/23/2019	Alamitos Creek	4.1	68	900.226000319202
10/23/2019	Alamitos Creek	5.3	72	900.226000319226
10/28/2019	Calero Creek	14.6	107	900.226000319286
10/28/2019	Calero Creek	250.1	280	900.228000613713
10/28/2019	Calero Creek	7.9	85	900.226000319259
10/28/2019	Calero Creek	12.3	95	900.226000319207
10/28/2019	Calero Creek	8.5	86	900.226000319245
10/28/2019	Calero Creek	12.4	96	900.226000319285
10/28/2019	Calero Creek	6.6	81	900.226000319297
10/30/2019	Guadalupe River	169.6	248	900.228000613714
10/31/2019	Alamitos Creek	8.5	90	900.226000319251
10/31/2019	Alamitos Creek	15.9	103	900.226000319262
10/31/2019	Alamitos Creek	15.1	105	982.126058146089
10/31/2019	Alamitos Creek	6.6	80	982.126058146053
10/31/2019	Alamitos Creek	281.8	280	900.228000613715
10/31/2019	Alamitos Creek	60.3	170	900.228000613718
10/31/2019	Alamitos Creek	40.1	150	900.228000613717

10/31/2019	Alamitos Creek	65.4	173	900.228000613716
10/31/2019	Alamitos Creek	7	81	900.226000319270
10/31/2019	Alamitos Creek	12.2	99	900.226000319232
10/31/2019	Alamitos Creek	28.8	134	900.226000319213
10/31/2019	Alamitos Creek	11.7	95	900.226000319241
10/31/2019	Alamitos Creek	5.8	75	900.226000319267
10/31/2019	Alamitos Creek	10.7	90	900.226000319298
10/31/2019	Alamitos Creek	6.3	76	900.226000319299
10/31/2019	Alamitos Creek	13.4	98	900.226000319234
10/31/2019	Alamitos Creek	11.6	93	900.226000319271
10/31/2019	Alamitos Creek	11.9	99	900.226000319255
10/31/2019	Alamitos Creek	11.5	95	900.226000319238
10/31/2019	Alamitos Creek	6.9	77	900.226000319283
10/31/2019	Alamitos Creek	25.4	130	900.226000319253
10/31/2019	Alamitos Creek	12	96	900.226000319229
10/31/2019	Alamitos Creek	14.1	97	900.226000319275
10/31/2019	Alamitos Creek	20.2	115	900.226000319279
10/31/2019	Alamitos Creek	33.6	140	982.126058146080
10/31/2019	Alamitos Creek	18.9	112	982.126058146069
10/31/2019	Alamitos Creek	19.5	117	982.126058146081
11/4/2019	Upper Penitencia Creek	96.5	209	900.228000613720
11/4/2019	Upper Penitencia Creek	171.5	245	900.228000613732
11/4/2019	Upper Penitencia Creek			900.228000613722
11/4/2019	Upper Penitencia Creek	7.8	85	982.126058146039
11/4/2019	Upper Penitencia Creek	11.3	93	982.126058146070
11/4/2019	Upper Penitencia Creek	63.9	177	900.228000613723
11/4/2019	Upper Penitencia Creek	59.4	178	900.228000613724
11/4/2019	Upper Penitencia Creek	8.5	84	982.126058146084
11/4/2019	Upper Penitencia Creek		79	982.126058146042
11/4/2019	Upper Penitencia Creek	24.1	130	982.126058146043
11/4/2019	Upper Penitencia Creek		106	982.126058146105
11/4/2019	Upper Penitencia Creek	12	92	982.126058146111
11/4/2019	Upper Penitencia Creek	7.6	84	982.126058146100
11/4/2019	Upper Penitencia Creek	17.3	108	982.126058146116
11/4/2019	Upper Penitencia Creek	48.2	162	900.228000613726
11/4/2019	Upper Penitencia Creek	10.8	92	982.126058146058
11/4/2019	Upper Penitencia Creek	41.1	158	900.228000613727
11/4/2019	Upper Penitencia Creek	5.2	73	982.126058146095
11/4/2019	Upper Penitencia Creek	7.2	85	982.126058146103
11/4/2019	Upper Penitencia Creek	15.5	103	982.126058146046
11/4/2019	Upper Penitencia Creek	10.7	100	982.126058146074
11/4/2019	Upper Penitencia Creek	5.8	78	982.126058146076
11/4/2019	Upper Penitencia Creek	41.9	156	900.228000613728
11/4/2019	Upper Penitencia Creek	38.6	145	982.126058146034
11/4/2019	Upper Penitencia Creek	49.2	162	900.228000613730
11/4/2019	Upper Penitencia Creek	12.5	101	982.126058146096
11/4/2019	Upper Penitencia Creek	6.2	78	982.126058146055

11/4/2019	Upper Penitencia Creek	13.3	96	982.126058146033
11/4/2019	Upper Penitencia Creek	8.7	88	982.126058146037
11/4/2019	Upper Penitencia Creek	6.9	83	982.126058146063
11/4/2019	Upper Penitencia Creek	13.1	102	982.126058146071
11/4/2019	Upper Penitencia Creek	143.1	234	900.228000613729
11/4/2019	Upper Penitencia Creek	5.8	75	982.126058146129
11/4/2019	Upper Penitencia Creek	55.3	172	900.228000613731
11/4/2019	Upper Penitencia Creek	11.5	98	982.126058146079
11/4/2019	Upper Penitencia Creek	19.2	112	982.126058146068
11/4/2019	Upper Penitencia Creek	6.2	79	982.126058146092
11/4/2019	Upper Penitencia Creek	7.9	86	982.126058146056
11/4/2019	Upper Penitencia Creek	5.2	74	982.126058146054
11/4/2019	Upper Penitencia Creek	6	76	982.126058146126
11/4/2019	Upper Penitencia Creek	17.8	111	982.126058146117
11/4/2019	Upper Penitencia Creek	15.1	108	982.126058146065
11/4/2019	Upper Penitencia Creek	9.9	94	982.126058146106
11/4/2019	Upper Penitencia Creek	9.1	88	982.126058146036
11/4/2019	Upper Penitencia Creek	19.7	112	982.126058146064
11/4/2019	Upper Penitencia Creek	7	79	982.126058146101
11/4/2019	Upper Penitencia Creek	9.3	89	982.126058146077
11/4/2019	Upper Penitencia Creek	75.1	189	900.228000613719
11/4/2019	Upper Penitencia Creek	12.4	97	982.126058146093
11/4/2019	Upper Penitencia Creek	5.1	74	982.126058146083
11/4/2019	Upper Penitencia Creek	13.8	105	982.126058146067
11/4/2019	Upper Penitencia Creek	4.5	73	982.126058146044
11/4/2019	Upper Penitencia Creek	8.7	91	982.126058146085
11/4/2019	Upper Penitencia Creek	5.3	77	982.126058146087
11/4/2019	Upper Penitencia Creek	6.3	81	982.126058146048
11/4/2019	Upper Penitencia Creek	8.7	90	982.126058146062
11/4/2019	Upper Penitencia Creek	6.3	78	982.126058146041
11/4/2019	Upper Penitencia Creek	13.9	101	982.126058146098
11/4/2019	Upper Penitencia Creek	5.5	77	982.126058146113
11/4/2019	Upper Penitencia Creek	5.1	74	982.126058146115
11/4/2019	Upper Penitencia Creek	8.6	90	982.126058146088
11/4/2019	Upper Penitencia Creek	151.3	236	900.228000613721
11/6/2019	Coyote Creek	18.1	112	982.126058146078
11/6/2019	Coyote Creek	28.2	133	982.126058146107
11/6/2019	Coyote Creek	23.2	122	982.126058146114
11/13/2019	Upper Penitencia Creek	54.7	168	900.228000613736
11/13/2019	Upper Penitencia Creek	35.2	149	982.126058146075
11/13/2019	Upper Penitencia Creek	147.8	238	900.228000613738
11/13/2019	Upper Penitencia Creek	46.3	159	900.228000613739
11/13/2019	Upper Penitencia Creek	23.5	124	982.126058146102
11/13/2019	Upper Penitencia Creek	68.9	184	900.228000613740
11/13/2019	Upper Penitencia Creek	119.5	224	900.228000613742
11/13/2019	Upper Penitencia Creek	7.5	84	982.126058146051
11/13/2019	Upper Penitencia Creek	7.5	86	982.126058146038

11/13/2019	Upper Penitencia Creek	30.5	140	982.126058146123
11/13/2019	Upper Penitencia Creek	9.8	88	982.126058146057
11/13/2019	Upper Penitencia Creek	12.2	97	982.126058146032
11/13/2019	Upper Penitencia Creek	8.7	80	982.126058146073
11/13/2019	Upper Penitencia Creek	23.6	125	982.126058146047
11/13/2019	Upper Penitencia Creek	15.7	94	982.126058146122
11/13/2019	Upper Penitencia Creek	13.8	94	982.126058146049
11/13/2019	Upper Penitencia Creek	9.1	86	982.126058146109
11/13/2019	Upper Penitencia Creek	8.8	84	982.126058146052
11/13/2019	Upper Penitencia Creek	24.5	124	982.126058146099
11/13/2019	Upper Penitencia Creek	26.3	128	982.126058146128
11/13/2019	Upper Penitencia Creek	73.5	184	900.228000613743
11/13/2019	Upper Penitencia Creek	38.5	134	982.126058146124
11/13/2019	Upper Penitencia Creek	2.9	84	982.126058146045
11/13/2019	Upper Penitencia Creek	110.3	209	900.228000613744
11/13/2019	Upper Penitencia Creek	28.9	132	982.126058146108
11/13/2019	Upper Penitencia Creek	12.4	96	982.126058146090
11/13/2019	Upper Penitencia Creek	37.2	154	982.126058146059
11/13/2019	Upper Penitencia Creek	96.5	204	900.228000613737
11/13/2019	Upper Penitencia Creek	31.8	141	982.126058146110
11/13/2019	Upper Penitencia Creek	10.6	95	982.126058146131
11/13/2019	Upper Penitencia Creek	38.8	153	900.228000613734
11/13/2019	Upper Penitencia Creek	24.8	128	982.126058146118
11/13/2019	Upper Penitencia Creek	20.4	125	982.126058146082
11/13/2019	Upper Penitencia Creek	58.2	172	900.228000613735
8/4/2020	Upper Penitencia Creek	38.2	147	982.126058146943
8/4/2020	Upper Penitencia Creek		144	982.126058146121
8/4/2020	Upper Penitencia Creek	25.4	129	982.126058146947
8/4/2020	Upper Penitencia Creek	22.2	121	982.126058146948
8/4/2020	Upper Penitencia Creek	39.3	152	900.228000613803
8/4/2020	Upper Penitencia Creek	59.1	178	900.228000613802
8/4/2020	Upper Penitencia Creek	124	237	900.228000613804
8/4/2020	Upper Penitencia Creek	31.5	142	982.126058146963
8/4/2020	Upper Penitencia Creek	36.1	151	900.228000613801
8/4/2020	Upper Penitencia Creek	79.4	196	900.228000613806
8/4/2020	Upper Penitencia Creek		104	982.126058146086
8/4/2020	Upper Penitencia Creek	26.4	130	982.126058146954
8/4/2020	Upper Penitencia Creek		123	982.126058146066
10/21/2020	Guadalupe Creek	3.9	67	982.126058146127
10/21/2020	Guadalupe Creek	6.4	78	982.126058146094
10/21/2020	Guadalupe Creek	4.1	71	982.126058146060
10/21/2020	Guadalupe Creek	59.7	184	900.228000613747
10/21/2020	Guadalupe Creek	5.8	82	982.126058146130
10/21/2020	Guadalupe Creek	8.1	83	982.126058146119
10/21/2020	Guadalupe Creek	10.5	97	982.126058146050
10/21/2020	Guadalupe Creek	17.5	118	982.126058146061
10/21/2020	Guadalupe Creek	11.2	99	982.126058146104

10/22/2020	Guadalupe Creek	4.5	71	982.126058146072
10/28/2020	Stevens Creek	21	122	982.126058146870
10/28/2020	Stevens Creek	15.1	105	982.126058146097
10/28/2020	Stevens Creek	24.2	125	982.126058146872
10/28/2020	Stevens Creek	34.5	146	982.126058146923
10/28/2020	Stevens Creek	4.4	68	982.126058146881
10/28/2020	Stevens Creek	15.6	103	982.126058146902
10/28/2020	Stevens Creek	48.5	162	900.228000613748
10/28/2020	Stevens Creek	4.8	70	982.126058146867
10/28/2020	Stevens Creek	3.8	69	982.126058146909
10/28/2020	Stevens Creek	4.3	69	982.126058146926
10/28/2020	Stevens Creek	4.5	69	982.126058146911
10/29/2020	Stevens Creek	4.6	66	982.126058146903
10/29/2020	Stevens Creek	4.8	69	982.126058146908
10/29/2020	Stevens Creek	3.9	68	982.126058146927
10/29/2020	Stevens Creek	4.1	68	982.126058146919
10/29/2020	Stevens Creek	3.3	67	982.126058146891
10/29/2020	Stevens Creek	5.1	71	982.126058146913
10/29/2020	Stevens Creek	6.1	75	982.126058146914
10/29/2020	Stevens Creek	4.4	71	982.126058146892
10/29/2020	Stevens Creek	4.5	69	982.126058146890
10/29/2020	Stevens Creek	4.4	69	982.126058146861
10/29/2020	Stevens Creek	6.6	78	982.126058146875
10/29/2020	Stevens Creek	6.2	78	982.126058146920
10/29/2020	Stevens Creek	13.1	100	982.126058146874
10/29/2020	Stevens Creek	4.3	65	982.126058146899
10/29/2020	Stevens Creek	34.6	141	982.126058146900
10/29/2020	Stevens Creek	4.2	72	982.126058146858
10/29/2020	Stevens Creek	8.6	82	982.126058146924
10/29/2020	Stevens Creek	9.5	88	982.126058146888
10/29/2020	Stevens Creek	4.9	74	982.126058146922
10/29/2020	Stevens Creek	4.9	71	982.126058146931
10/29/2020	Stevens Creek	4.2	70	982.126058146918
10/29/2020	Stevens Creek	4.4	67	982.126058146925
10/29/2020	Stevens Creek	4.8	70	982.126058146886
10/29/2020	Stevens Creek	4.4	71	982.126058146897
10/29/2020	Stevens Creek	5	71	982.126058146921
10/29/2020	Stevens Creek	3.7	69	982.126058146928
11/2/2020	Calero Creek	5.2	74	982.126058146917
11/2/2020	Calero Creek	7.4	86	982.126058146847
11/2/2020	Calero Creek	3.7	66	982.126058146876
11/2/2020	Calero Creek	3.8	68	982.126058146850
11/2/2020	Calero Creek	8.9	87	982.126058146869
11/2/2020	Calero Creek	5.1	70	982.126058146859
11/2/2020	Calero Creek	2.9	66	982.126058146894
11/2/2020	Calero Creek	5.8	81	982.126058146841
11/2/2020	Calero Creek	6.2	76	982.126058146889

11/2/2020	Calero Creek	12.9	99	982.126058146860
11/2/2020	Calero Creek	7.6	86	982.126058146849
11/2/2020	Calero Creek	4.9	72	982.126058146856
11/2/2020	Calero Creek	6.5	81	982.126058146845
11/2/2020	Calero Creek	7.1	84	982.126058146904
11/2/2020	Calero Creek	11.3	97	982.126058146834
11/2/2020	Calero Creek	4.6	73	982.126058146863
11/2/2020	Calero Creek	9.1	90	982.126058146901
11/2/2020	Calero Creek	11	96	982.126058146896
11/2/2020	Calero Creek	295.5	290	900.228000613749
11/2/2020	Calero Creek	3.6	66	982.126058146910
11/2/2020	Calero Creek	3.9	67	982.126058146871
11/2/2020	Calero Creek	5.3	75	982.126058146912
11/2/2020	Calero Creek	4.1	71	982.126058146893
11/2/2020	Calero Creek	6.7	82	982.126058146833
11/2/2020	Calero Creek	4.8	71	982.126058146906
11/2/2020	Calero Creek	4	70	982.126058146915
11/2/2020	Calero Creek	7.2	81	982.126058146930
11/2/2020	Calero Creek	8.5	88	982.126058146862
11/2/2020	Calero Creek	5.7	73	982.126058146884
11/2/2020	Calero Creek	5.5	79	982.126058146887
11/9/2020	Alamitos Creek	157.8	239	900.228000613750
11/9/2020	Alamitos Creek	26.1	133	982.126058146864
11/9/2020	Alamitos Creek	14.6	94	982.126058146879
11/9/2020	Alamitos Creek	16.5	103	982.126058146898
11/9/2020	Alamitos Creek	19.4	106	982.126058146873
11/9/2020	Alamitos Creek	16.2	111	982.126058146851
11/9/2020	Alamitos Creek	162.5	240	900.228000613752
11/9/2020	Alamitos Creek	80	192	900.228000613751
11/9/2020	Alamitos Creek	25.8	125	982.126058146929
11/9/2020	Alamitos Creek	27.8	138	982.126058146854
11/9/2020	Alamitos Creek	9.8	95	982.126058146857
11/10/2020	Alamitos Creek	19.7	123	982.126058146838
11/10/2020	Alamitos Creek	6.6	79	982.126058146832
11/10/2020	Alamitos Creek	15.4	117	982.126058146916
11/10/2020	Alamitos Creek	23.1	132	982.126058146852
11/10/2020	Alamitos Creek	25.9	136	982.126058146868
11/12/2020	Alamitos Creek	29.7	135	982.126058146853
11/12/2020	Alamitos Creek	23.7	129	982.126058146839
11/12/2020	Alamitos Creek	9.8	90	982.126058146843
11/12/2020	Alamitos Creek	20.1	113	982.126058146877
11/12/2020	Alamitos Creek	31.5	133	982.126058146836
11/12/2020	Alamitos Creek	18.4	110	982.126058146878
11/18/2020	Guadalupe Creek	28.4	145	982.126058146882

Coyote Creek 2019-2020 Adult Salmonid Migration Monitoring Using the Vaki Riverwatcher Passive Monitoring System at the Coyote Percolation Dam Fish Ladder

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March 2021

Contents

Tables

Figures

Appendices

Introduction

Steelhead (*Oncorhynchus mykiss, O. mykiss* for the remainder of the document) in the Central California Coast (CCC) Distinct Population Segment (DPS) were listed as threatened by the National Marine Fisheries Service (NMFS) in 1997. Due to their protected status, Valley Water (formerly the Santa Clara Valley Water District) implemented a noninvasive means of documenting adult steelhead escapement in Coyote Creek using the Vaki Riverwatcher (Vaki) System. The Vaki is a computer-based fish counter that employs scanner plates and a digital camera to capture videos and silhouette images of fish as they pass between the plates. The Vaki provides information on the occurrence and timing of adult fish migration both upstream and downstream through the counter. This monitoring also allows for detections of other anadromous fish such as Chinook salmon (*Oncorhynchus tshawytscha*) and Pacific lamprey (*Entosphenus tridentatus*).

The Coyote Creek Vaki unit was installed within the fish ladder at the Coyote Percolation Facility during the migration season (October to May). The fish ladder was constructed in 1999 to enable fish passage around the Coyote Diversion Dam, which had previously created an impassable barrier to fish migration. The first Coyote Creek Vaki monitoring period was the 2018-2019 migration season. In October 2019, the Vaki was installed for a second monitoring period and is the focus of this report.

Installation, Operation, and Maintenance

The Coyote Percolation Facility fish ladder is located 51 kilometers upstream of the South San Francisco Bay on Coyote Creek and immediately downstream of Metcalf Pond between Metcalf Road and Highway 101 (Figure 1). The Vaki was installed within the fish ladder on October 2, 2019, as seen in Figure 2. The counter itself is a rectangular-shaped unit outfitted with scanner plates, a camera, and infrared light-emitting diodes on the interior (Figure 3) and is completely submerged underwater within the fish ladder. Adult fish are directed through the counter opening by use of weirs in the ladder. When a fish swims through the counter and breaks the plane of light beams, the fish is scanned and a resulting silhouette image is sent to the onsite computer. Other information recorded during each detection includes the speed the fish was traveling, the direction the fish was moving (upstream or downstream), body depth (for estimating length based on length-to-depth ratios from the literature), along with the date and time of the detection. A detection also triggers a digital camera that records a 4.1-second video for fish traveling upstream and a 14.4-second video for fish traveling downstream. However, due to issues in programing the software, the Coyote Creek Vaki camera recorded 9.9 second videos for fish traveling upstream and 19.8 second videos for fish traveling downstream for a portion of the monitoring season. The videos are used to confirm the presence of a fish and improve confidence in species identification.

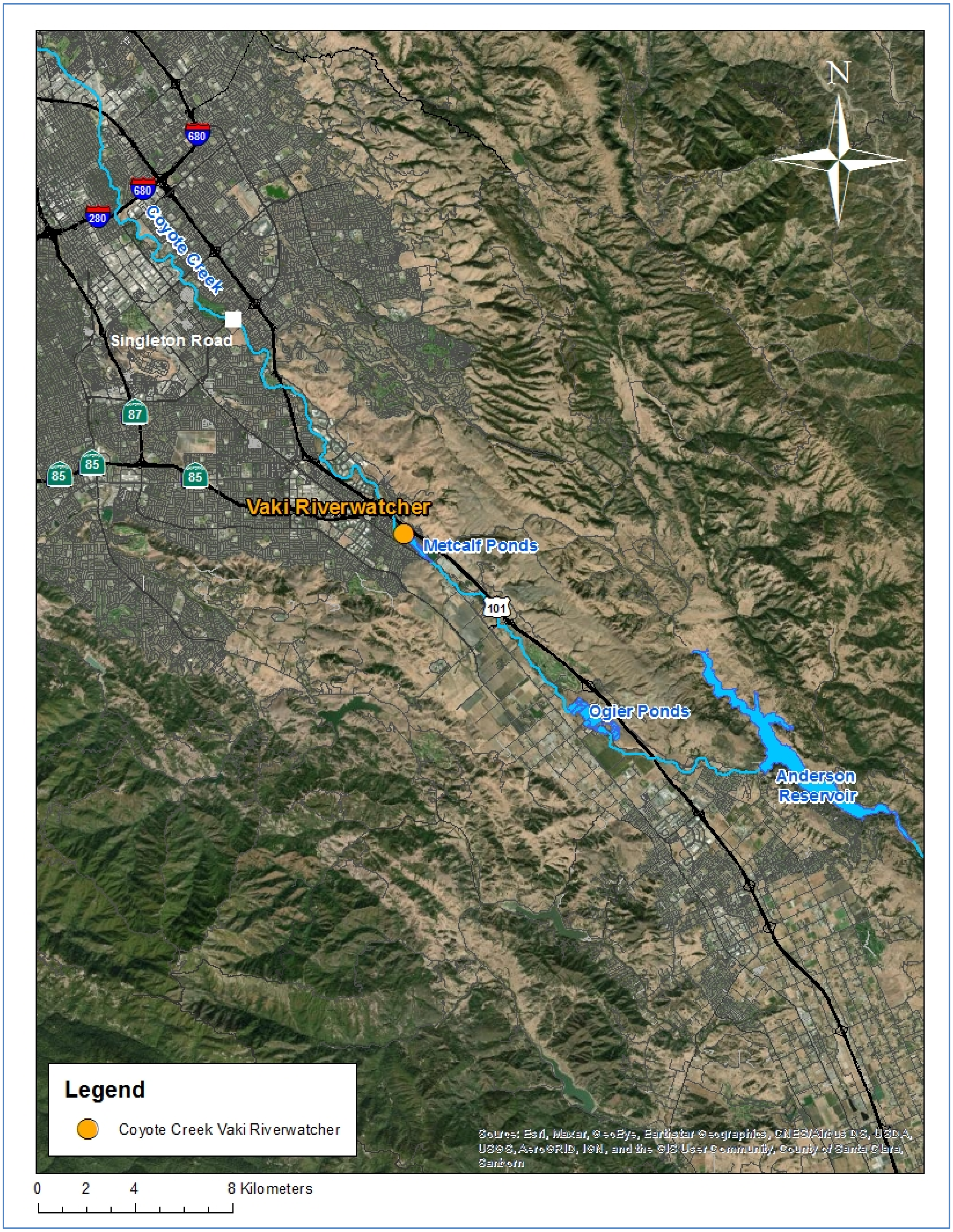

Figure 1. Coyote Creek Vaki Riverwatcher location.

Figure 2. Installation of the Vaki Riverwatcher system in the Coyote Creek Fishway on October 2, 2019. The red box indicates the fish counter.

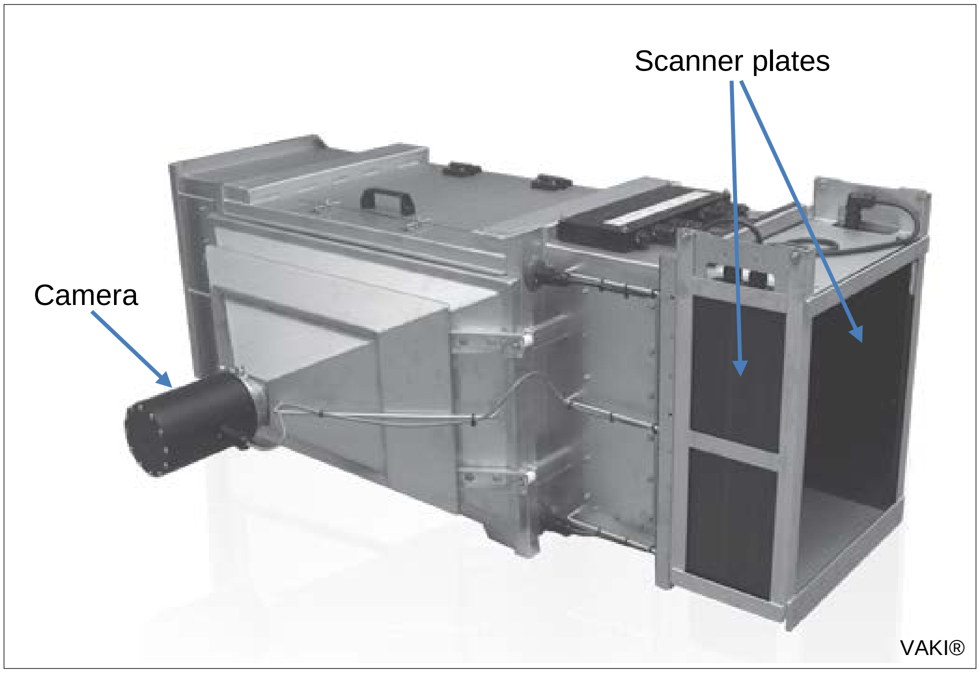

Figure 3. Vaki Riverwatcher fish counter.

All the data collected by the Vaki were stored on the attached onsite computer. Data was manually downloaded from the computer up to twice per week and transferred to the Valley Water network. Once the data was downloaded, the onsite computer database was reset. The files were vetted by Valley Water staff as soon as possible following the download. During the biweekly visits to download data, Valley Water staff also performed maintenance by cleaning debris and algal build-up on the scanner plates and plexiglass in front of the camera with a Mr. Long Arm® brush.

The Vaki was attached directly to the AC power grid operated by Pacific Gas and Electric (PG&E). After any power outages, the onsite computer was unable to automatically reopen the Vaki software causing gaps in the data until the Vaki was visited and the program was manually reopened. An outage on October 24, 2019 resulting from a PG&E power shut-off caused a 7.5-day gap in recorded data since the Vaki was not visited until a week after the outage to reopen the software program. For six days in February, the cable connecting the counter to the onsite computer was damaged, and detections were not recorded until the cable was replaced on February

26, 2020. Lastly, data was not recorded for another six days in March due to a power outage. Time periods in which data was not recorded are detailed in Table 1. It is possible for migrating fish to have been missed during these time periods, which add up to a total of approximately 20 full days when fish were not being monitored.

Table 1. 2019-2020 Vaki outage durations and causes.

Duration of outage (hours)	Cause of outage	Start of outage	End of outage
185	Power outage	10/24/2019 18:13	11/1/2019 11:59
144	Damaged cable	2/20/2020 13:35	2/26/2020 13:54
143	Power outage	3/17/2020 15:38	3/23/2020 15:00
Total duration of outage: 472 hours (approx. 20 days)			

Due to the COVID-19 shelter-in-place order that went into effect in Santa Clara County in March 2020, the Vaki was not checked between March 10 and March 22. Vaki maintenance was considered essential work; therefore, Valley Water staff resumed checking the Vaki but reduced the number of checks to approximately one per week. Masks were worn and social distancing guidelines were adhered to during visits.

The Vaki was powered off for the season on May 19, 2020 and removed from the fish ladder on May 30, 2020.

Data Analysis

The Vaki recorded silhouettes and videos of all items large enough to break the plane of the diodes (body depth of 40 mm or greater). Scanned infrared silhouettes and video images were reviewed using the Winari software to ensure that only fish passage events were included in the overall passage counts. Videos were used to identify fish to species when conditions provided clear images, and silhouettes were also used to identify fish to species if identifying characteristics were present. Detections without accompanying videos were only sorted into specific species categories if the silhouette was clear and the confidence level of identification was high; otherwise, these detections were sorted into the “unknown fish” category. Videos with two or more species present were placed into the “multiple species” category, unless one of the species detected was an anadromous fish. A confidence level rating system analyzing both silhouette and video quality was used to rate the likelihood of accurate identification for anadromous fish (Table 2). This rating system was used for Pacific lamprey (*Entosphenus tridentatus*) as this was the only anadromous species detected by the Vaki during the 2019-2020 monitoring period.

Table 2. Confidence rating system used for identifying Vaki detections of anadromous fish species.

	High quality video	**Average quality video**	**Poor quality video**	**Video absent**
High quality silhouette	High confidence	High confidence	Medium confidence	Medium confidence
Average quality silhouette	High confidence	High confidence	Medium confidence	Low confidence
Poor quality silhouette	High confidence	Medium confidence	Low confidence	Can’t be categorized
Silhouette absent	High confidence	Medium confidence	Low confidence	N/A

The Vaki system is designed to track adult migratory fish with a clear migratory path (i.e., anadromous fish), but it does not provide the ability to estimate the number of fish using the habitat in which the system is installed. For Centrarchidae, Cyprinidae, Ictaluridae, and Catostomidae species that are not migrating, detection indicates presence but cannot be used to assess population numbers. These species were amalgamated by family for analysis and reporting purposes, but the species name was noted if positive identification was possible.

Partway through data review in fall 2020, a malfunction with the Winari software required a reboot of the entire database and all of the previously reviewed data was subsequently lost. However, prior to this malfunction, a technical memorandum prepared in July 2020 for the Federal Energy Regulatory Commission (FERC) Order Compliance Project summarized the results for the time periods when flows likely allowed for adult *O. mykiss* passage (December 1, 2019 to January 30, 2020 and March 14 to May 1, 2020). The memorandum reported the number of detections of anadromous fish species, unknown fish, and non-anadromous fish that were identified at least to the family level within those time periods. Because it would take a substantial amount of time to re-review all of the data and it had already been summarized, Valley Water staff focused on reviewing the data that was excluded from the memorandum once the Winari issue was resolved.

The July 2020 memorandum with the results of the preliminary review is provided in Appendix A.

Results

A total of 20,096 fish detections were recorded during the 2019-2020 monitoring season. Non-anadromous fish in the Catostomidae, Centrarchidae, Cyprinidae, and Ictaluridae families accounted for 16,612 of the detections, and 3,479 detections were placed in the unknown fish category.

The Centrarchidae species positively identified included largemouth bass (*Micropterus salmoides*) and bluegill (*Lepomis macrochirus*). Hitch (*Lavinia exilicauda*), common carp (*Cyprinus carpio*) and goldfish (*Carassius auratus*) were the Cyprinidae species that were positively identified, and the only Ictaluridae species positively identified by the Vaki included channel catfish (*Ictalurus punctatus*). Examples of positive species identifications can be seen in Appendix B.

No *O. mykiss* or Chinook salmon were identified during the 2019-2020 monitoring season. Pacific lamprey was the only anadromous fish species identified with a total of five detections occurring on April 25, 2020 and April 28, 2020; these detections were likely two individuals. Additionally, a Pacific lamprey was visually observed attached to the outside of the Vaki counter on April 22, 2020 while it was lifted out of the water for cleaning, but this observation was not included in the Vaki detection count. Though the Pacific lamprey detections were analyzed in the preliminary review, dates of detections were provided in the memorandum, so videos and silhouettes were re-reviewed in Winari in order to run them through the confidence matrix. Based on the confidence matrix (Table 2), three of the Pacific lamprey Vaki detections were rated high confidence (high quality video and silhouette), one was rated medium confidence (average quality video and poor quality silhouette), and one was rated low confidence due to an average quality silhouette and a video with no discernable lamprey present. All five lamprey detections were recorded moving upstream. The timing of the Pacific lamprey detections, as well as the Vaki outages, in relation to stream flow on Coyote Creek can be seen in Figure 4.

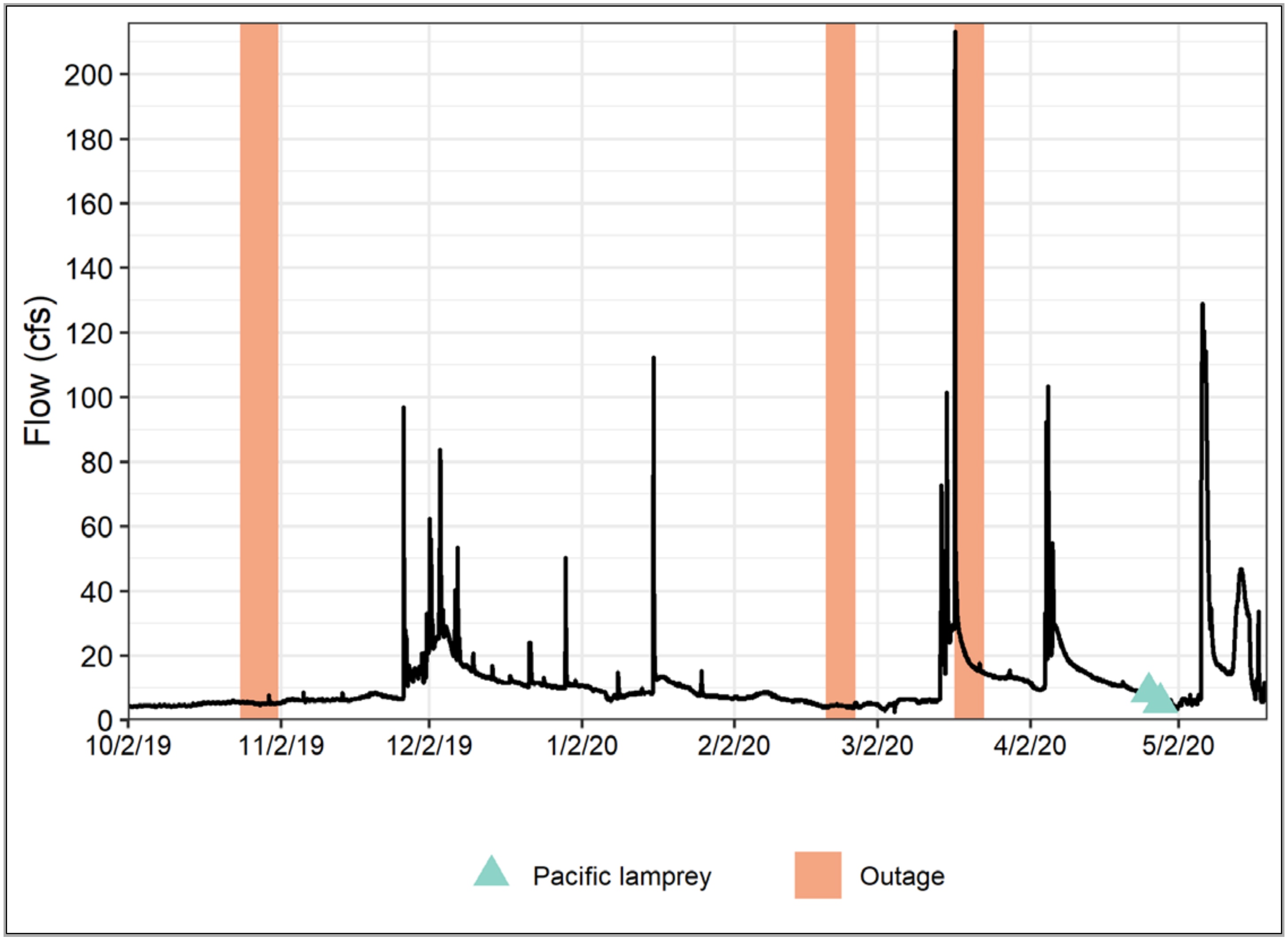

Figure 4. Pacific lamprey detections and Vaki outages in relation to stream flow (cubic feet per second) on Coyote Creek at Stream Gage ALERT 5058 at Edenvale. Note that lamprey detections occurred on two separate days, but multiple detections per day cannot be discerned.

Discussion

Based on the date and time of the Pacific lamprey Vaki detections, it is likely that the five detections were of two individuals. Due to Pacific lampreys' ability to latch onto walls and fit through small spaces, it is probable that additional lamprey went undetected by traversing around the Vaki counter. This presumption is further supported by the observation of a lamprey latched onto the outside of the counter during maintenance on April 22, 2020.

Though no adult *O. mykiss* or Chinook salmon detections were identified during the monitoring period, it is possible that they moved through the fish ladder during periods of time when the Vaki was non-operational. Per Moyle (2002), adult *O. mykiss* typically begin their upstream migration between December and March, peaking in January and February, while the Chinook salmon migration period occurs from October through January. The Vaki experienced three outages during the monitoring season, two of which occurred during the *O. mykiss* migration period (2/20/20-2/26/20 and 3/17/20-3/23/20) and one which occurred during the Chinook salmon migration period (10/24/19-11/1/19). While it is unlikely that *O. mykiss* moved through the fish ladder during the February outage due to low stream flows, it is possible that individuals went undetected while the Vaki was non-operational in March. The six-day March outage occurred immediately after the highest flow event of the season that could have triggered *O. mykiss* upstream movement. It is also unlikely that Chinook salmon moved through the fish ladder during the October-November outage due to low flows. However, there is the potential that *O. mykiss* and Chinook salmon actually were detected swimming through the Vaki but placed in the unknown fish category because the video or silhouette was not clear enough for identification.

The Vaki Riverwatcher is not designed to track the movement of juvenile *O. mykiss*, which may have gone unidentified during the monitoring season. The small size of the juvenile fish allows them to potentially swim through the weir bars outside of the Vaki or swim through the scanner plates without triggering the diodes, thus avoiding detection.

The 2019-2020 monitoring season overall had limited precipitation and limited stream flow, reducing opportunity for upstream passage of both *O. mykiss* and Chinook salmon.

References

Moyle, P. B. (2002). *Inland fishes of California*. Berkeley: University of California Press.

Valley Water (2020). Coyote Creek 2018-2019 Adult Salmonid Migration Monitoring Using the Vaki Riverwatcher Passive Monitoring System at the Coyote Percolation Dam Fish Ladder.

Appendix A

Coyote Creek Vaki Data Preliminary Review

Technical Memorandum

Valley Water

MEMORANDUM

FC 14 (08-21-19)

TO: Lisa Porcella **FROM**: Clayton Leal

SUBJECT: Coyote Creek Vaki Data Preliminary Review **DATE**: 7/17/2020

Steelhead (*Oncorhynchus mykiss, O. mykiss* for the remainder of the document) in the Central California Coast (CCC) Distinct Population Segment were listed as threatened by the National Marine Fisheries Service (NMFS) in 1997. Due to their protected status, Valley Water implemented a noninvasive means of documenting adult steelhead escapement in Coyote Creek. The equipment chosen to accomplish the task was the Vaki Riverwatcher (Vaki), a computer-based fish counter which employs scanner plates and a digital camera to capture videos and silhouette images of fish as they pass between the plates. This monitoring also allows for detections of other anadromous fish such as Chinook salmon (*Oncorhynchus tshawytscha*) and Pacific lamprey (*Entosphenus tridentatus*). The Vaki provides information on the occurrence and timing of adult fish migration both upstream and downstream through the counter. This unit was installed at the Coyote Percolation Facility within the fish ladder that provides passage over the instream diversion dam.

During the entire operating period (October 2 - May 19) a total of 24,101 data points were collected. This amounted to approximately 100 hours of videos, which is a substantial amount of staff time. The 2019-2020 migration season had limited precipitation and limited stream flow therefore reduced opportunity for upstream passage of anadromous fish. In order to complete the data review to be used in an evaluation for the Federal Energy Regulatory Commission (FERC) Order Compliance Project, data was reviewed only during a time period that we would expect adult *O. mykiss* would have been able to migrate. Figure 1 shows the stream flow during the December 2019 to May 2020 timeframe. Based on flow data it was determined that adult upstream passage was only likely to occur from December 1 to January 30 and then again from March 14 to May 1. The February 1 to March 13 timeframe had limited flows, and there was no passage opportunity for adult salmonids.

During the timeframe when passage could occur, the Vaki Riverwatcher recorded 9,103 data points. Of those videos 6,285 were identified to at least the level of family, while 1,169 were identified as fish, but could not be identified even to the level of family. The remaining 1,649 data points were deemed to not be fish.

No *O. mykiss* were identified during in any of the data analysis. The only anadromous species detected was Pacific lamprey. Five detection of Pacific lamprey occurred (April 25, 2020 and April 28, 2020), likely two individuals. Additionally, a Pacific lamprey was visually observed attached to the outside of the Vaki Riverwatcher on April 22, 2020 while the Vaki was being lifted to be cleaned.

The Vaki Riverwatcher experienced outages of operation during steelhead migration between 2/20/2020-2/26/2020 and 3/17/2020-3/23/2020. This was approximately 15 days of outages with only eight occurring during a time that migration was expected to be able to occur. Though no adult steelhead detections occurred during the monitoring period, it is possible that they moved through the fish ladder during the periods of time when the Vaki was non-operational or did not provide a clear enough silhouette or video to be identified.

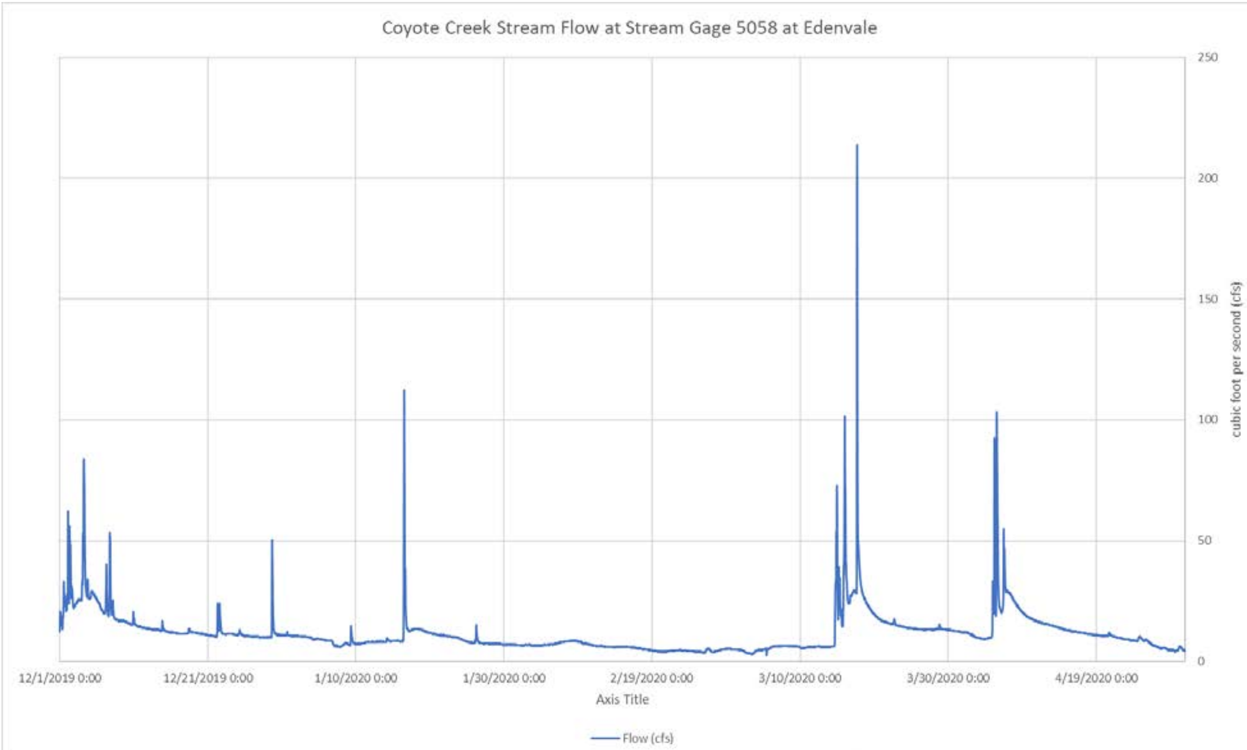

Figure 1: Stream flow on Coyote Creek at Stream Gage 5058 at Edenvale.

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Senior Water Resources Specialist
Environmental Mitigation and Monitoring Unit

Appendix B

Example Silhouettes and Video Images

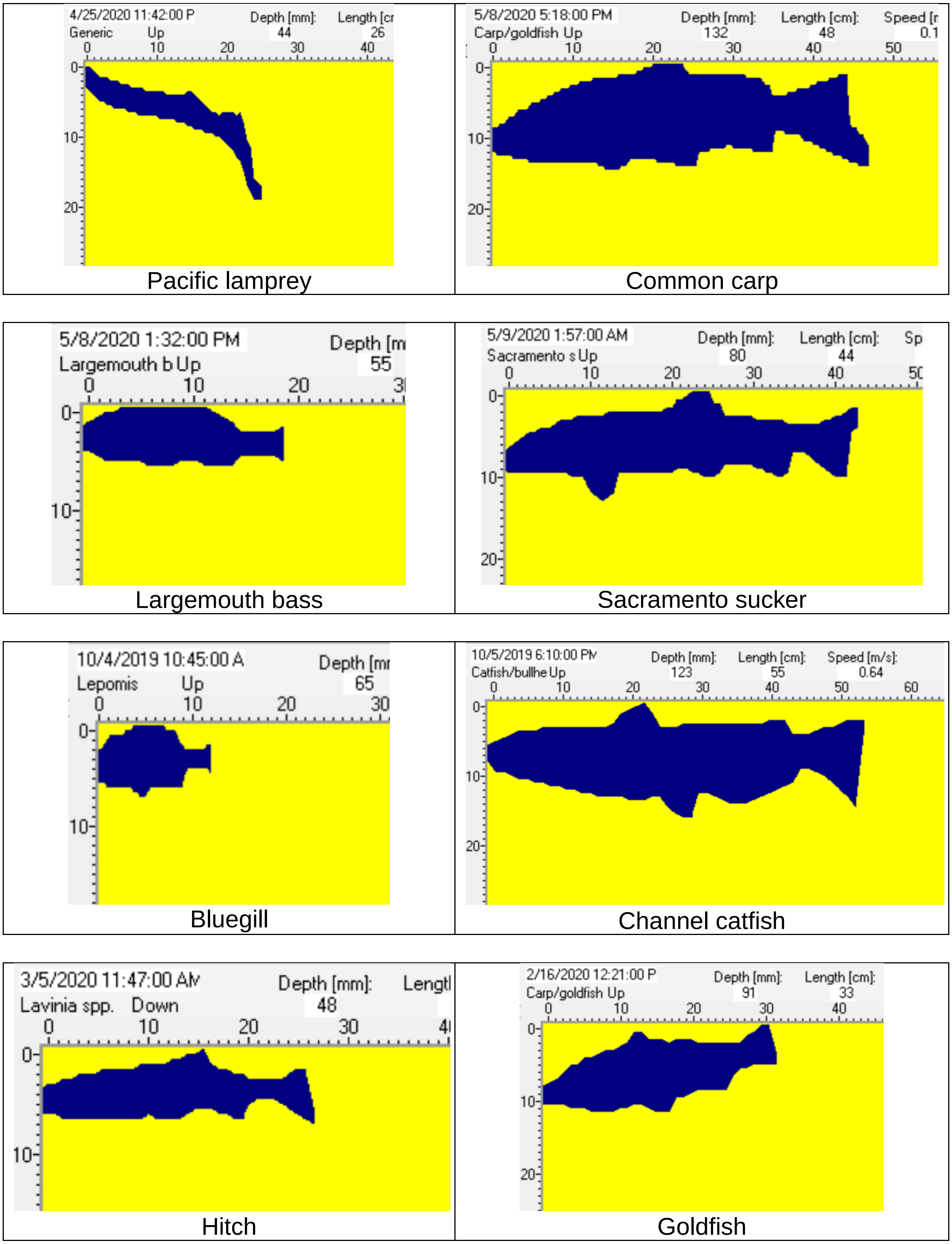

Figure B-1. Examples of silhouette images generated by the Vaki for each fish species referenced in the report.

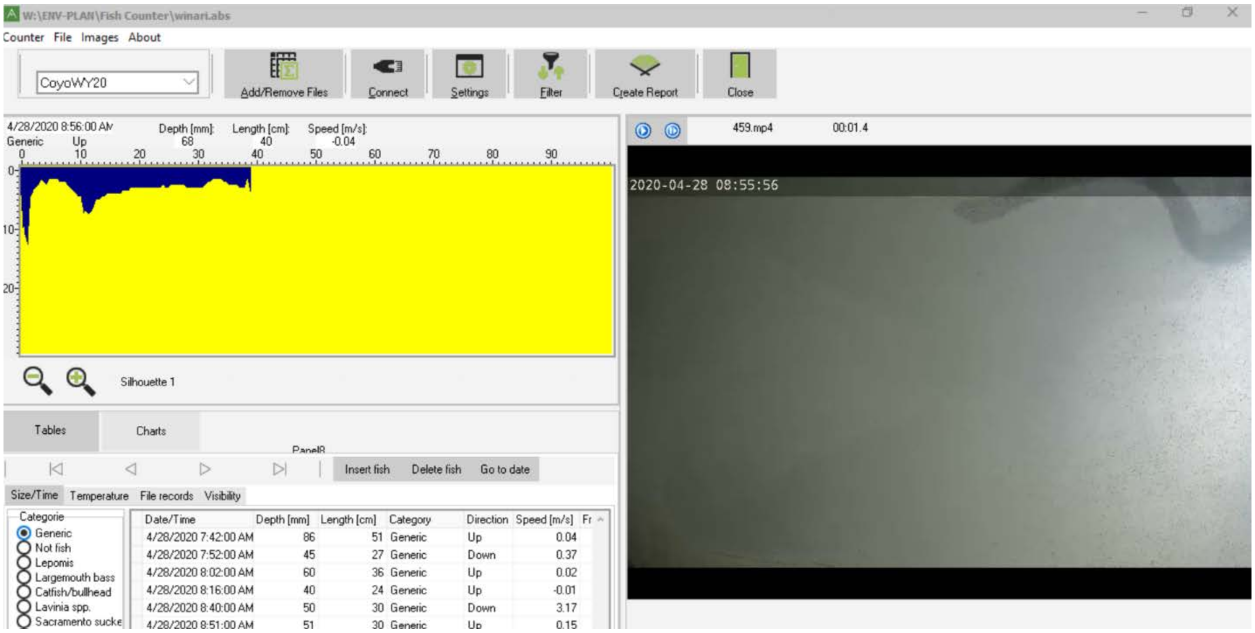

Figure B-2. Vaki video image of a Pacific lamprey (*Entosphenus tridentatus*).

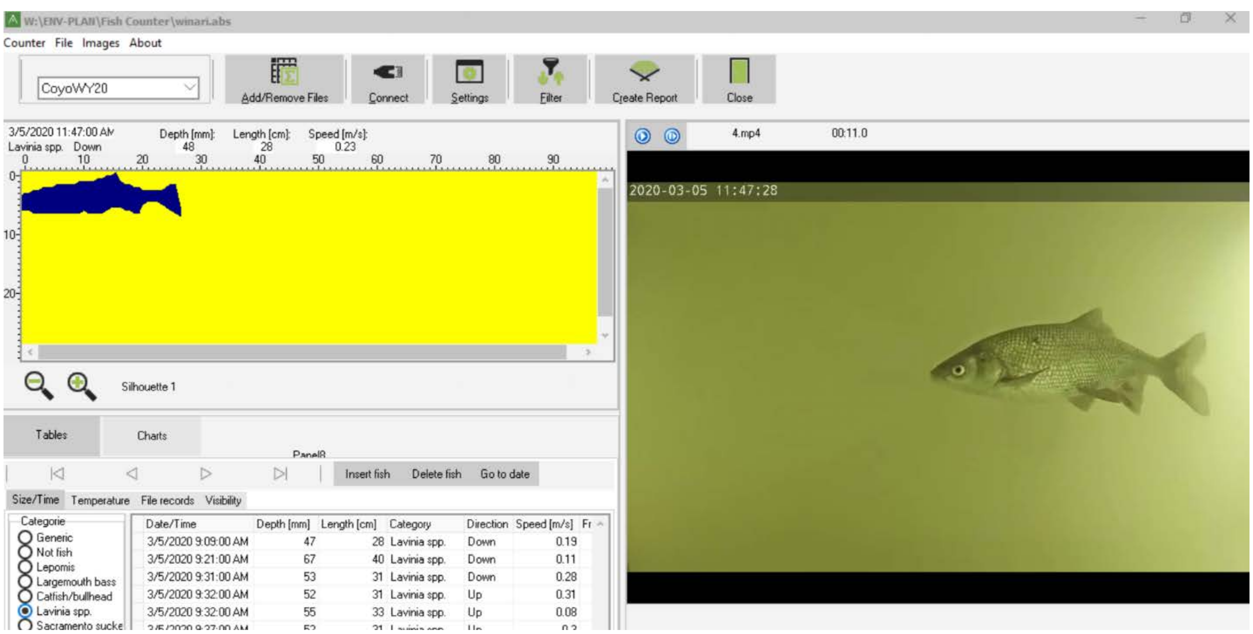

Figure B-3. Vaki video image of a Hitch (*Lavinia exilicauda*; classified as *Lavinia spp.*).

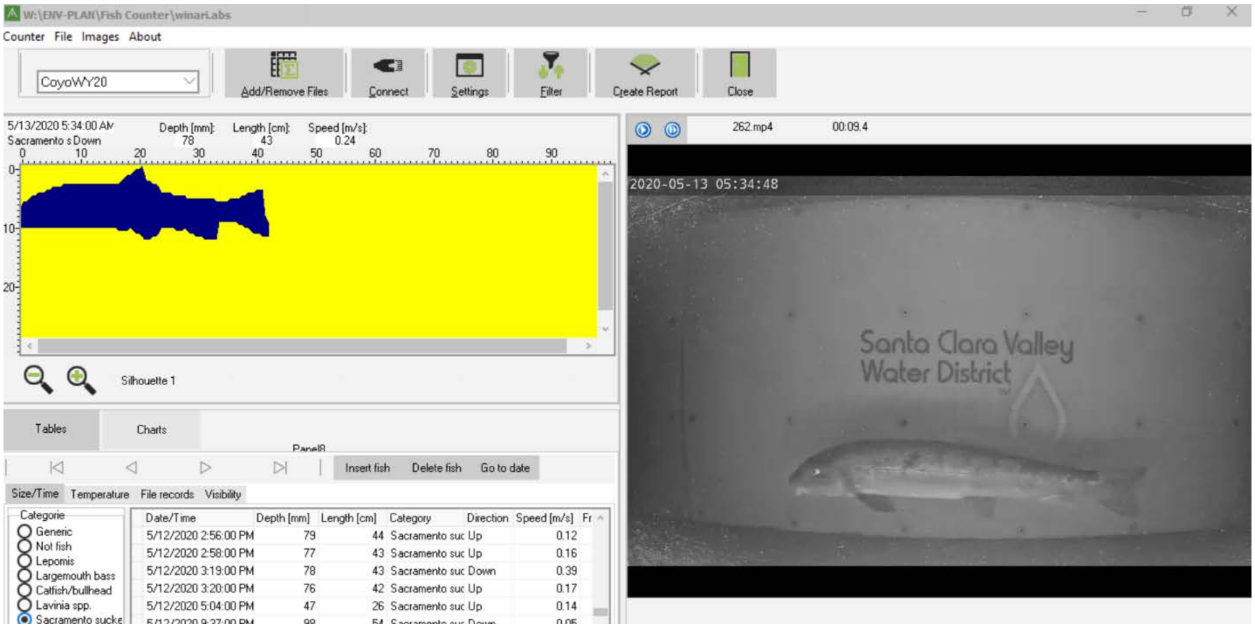

Figure B-4. Vaki video image of a Sacramento sucker (*Catostomus occidentalis*).

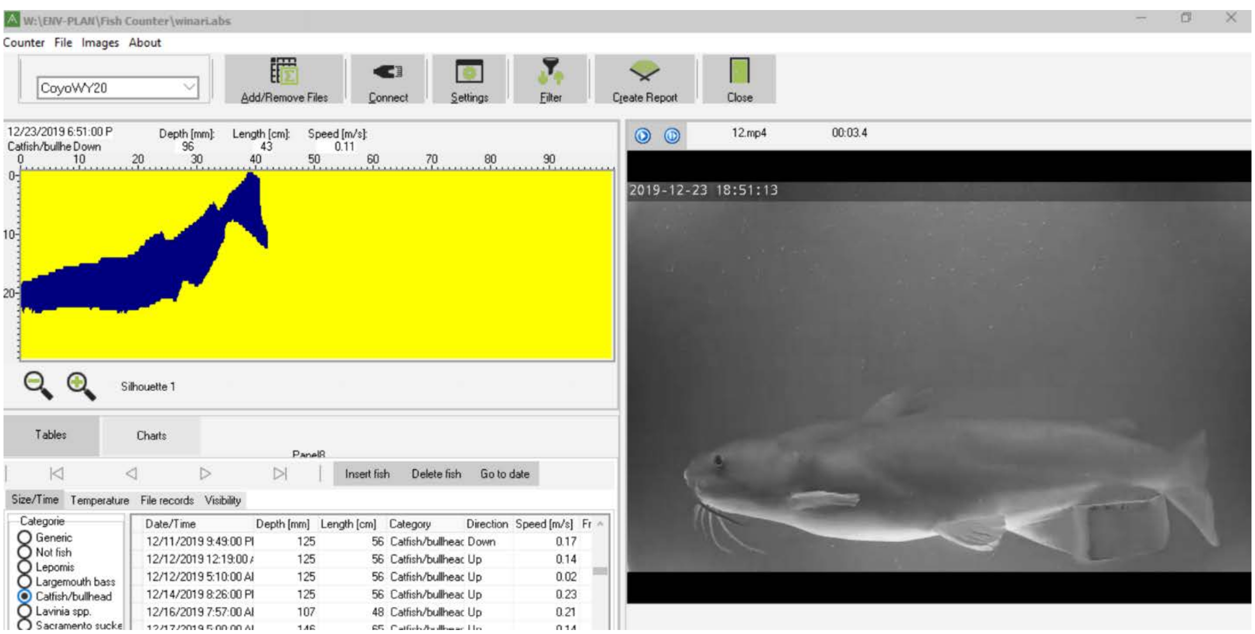

Figure B-5. Vaki video image of a Channel catfish (*Ictalurus punctatus*).

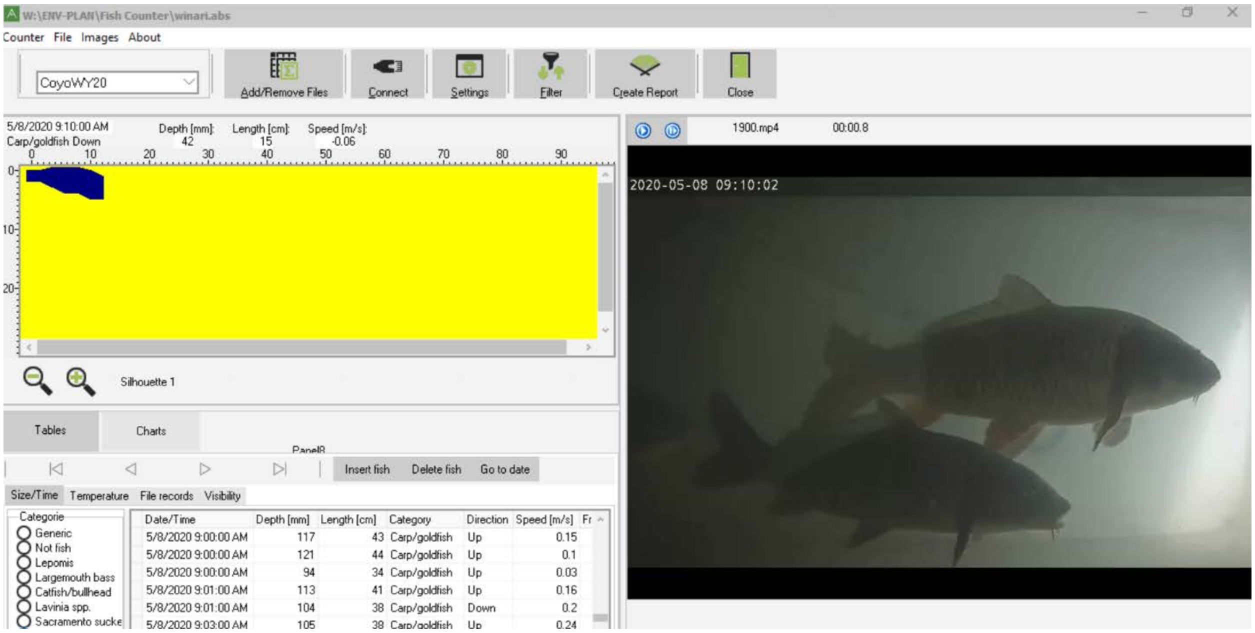

Figure B-6. Vaki video image of a Common carp (*Cyprinus carpio*).

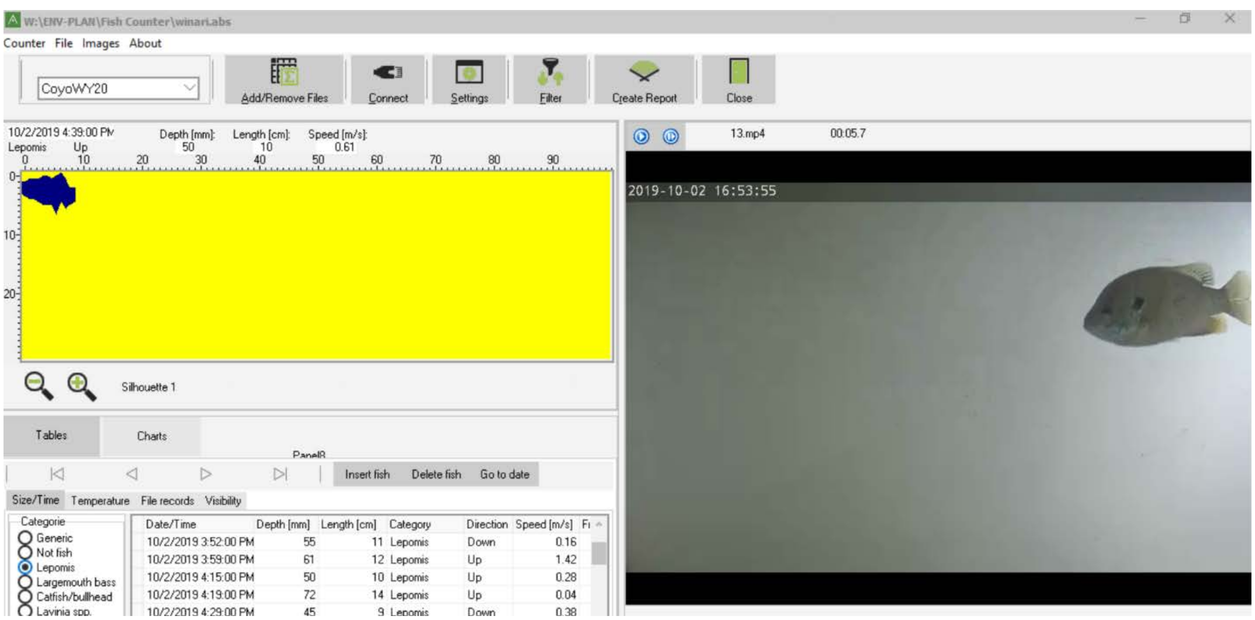

Figure B-7. Vaki video image of a Bluegill (*Lepomis macrochirus*; classified as *Lepomis spp*).

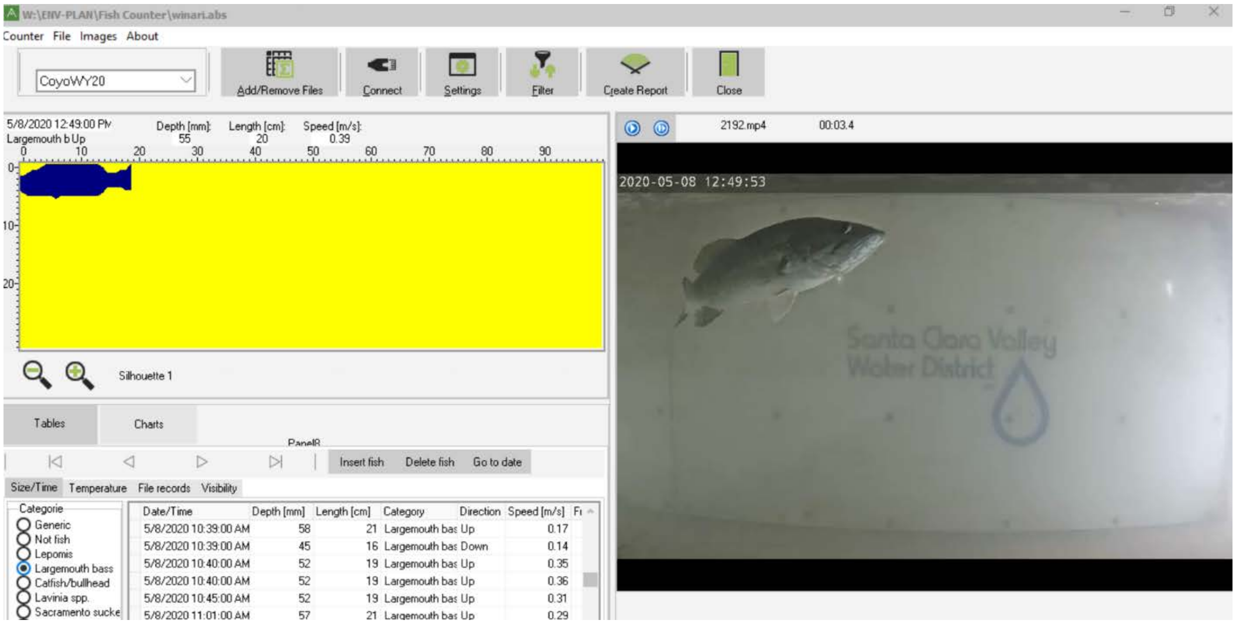

Figure B-8. Vaki video image of a Largemouth bass (*Micropterus salmoides*).

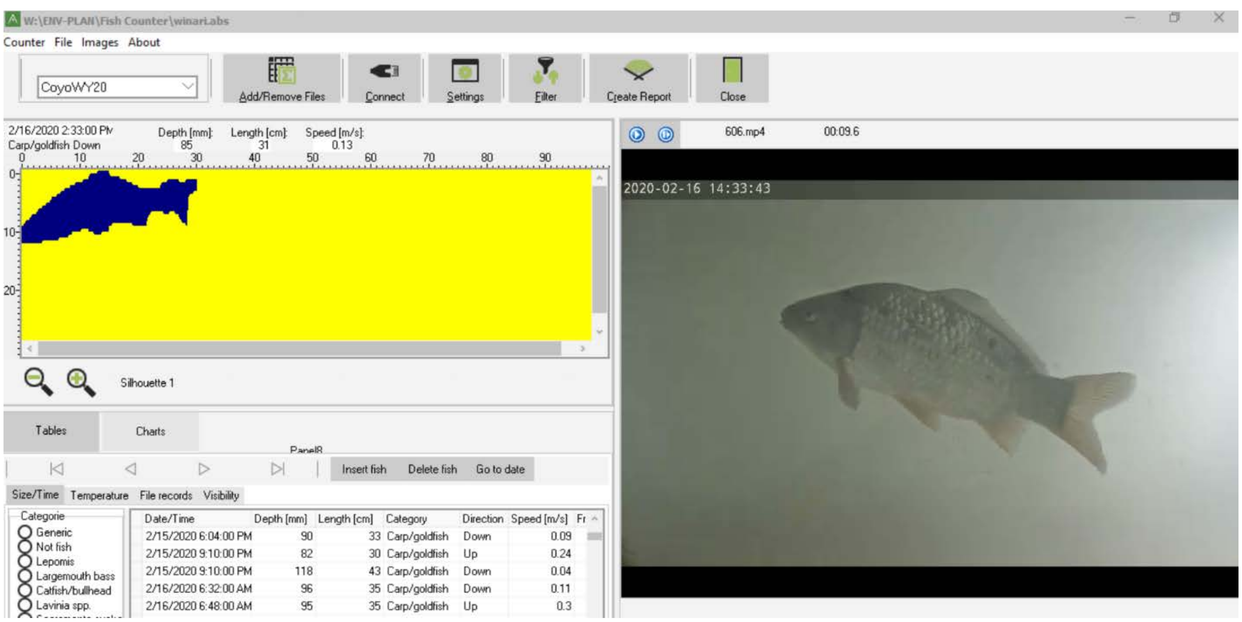

Figure B-9. Vaki video image of a Goldfish (*Carassius auratus)*.