Kings River Fisheries Management Program
March 2017

Lower Kings River Annual Trout and Non-Game Fish Population Survey:
2016 Electrofishing Results

Kings River Conservation District
Environmental Resource Division

In-House Report
2017

The Kings River Conservation District (KRCD), in cooperation with the California Department of Fish and Wildlife (CDFW) and the Kings River Water Association (KRWA), have conducted annual population surveys of rainbow trout *Oncorhynchus mykiss* and other fish inhabiting the lower Kings River downstream of Pine Flat Dam. Population surveys have been conducted from 1983 to the present. The population monitoring is performed as part of a Federal Energy Regulatory Commission (FERC) requirement for compliance with Item 4 of the Memorandum of Agreement for FERC Project No. 2741 and as part of the Kings River Fishery Management Program.

A multiple pass mark-and-recapture electrofishing survey was employed from 1983 through 1989. In 1990, the annual electrofishing survey was modified to a single pass count of captured trout using only a single block seine net at the upstream end of the sample reach. The decision to change to a single pass survey was made due to an absence of trout detected in the late 1980's as a result of extreme drought conditions and low flow conditions (KRCD 1993). The single pass reaches were expanded in length in an effort to locate trout. As a result of the change in survey methods the single pass data collected from 1990 through 2006 serve as an index of relative abundance and do not reflect absolute population density. Extrapolating density estimates from the single pass data produces, at best, results in uncertain estimates that do not stand up to rigorous statistical analysis. In the fall of 2007 the Fisheries Management Program's (FMP) Technical Steering Committee (KRCD, CDFW and the KRWA) revised the electrofishing survey protocol using a multiple (3) pass depletion technique with upstream and downstream block seines, which resulted in more confidence and reliable quantitative estimates of fish biomass, density, abundance, age, length and condition metrics for fish inhabiting the lower Kings River downstream of Pine Flat Dam. Results of the 2016 survey are presented below and compared to results of prior surveys.

Methods

In 2016 six survey sites (Figure 1) were sampled between November 9th and 18th using standard multiple-pass depletion electrofishing techniques (Reynolds 1996). Survey sites were 300 feet in length and both the upstream and downstream ends were netted with ¼-inch mesh

block seines to avoid fish immigration or emigration from the survey reach. Five to seven Smith-Root LR-24 and two Smith-Root LR-20B backpack electrofishers were utilized in the surveys.

Prior to the 2012 population survey, a series of tests were run using the LR-24 backpack electrofisher in the Kings River. These tests specifically targeted fish response in the presence of an electrical field. It was quickly determined that the previous settings (350volts, 10% Duty Cycle, 50Hz Frequency) were not providing enough power to the water based on the Power Transfer Theory (Kolz 1989) for efficient power transfer resulting in fish escape (fishes evading capture). The Power Transfer Theory states that power is efficiently transferred to the fish when the conductivity of the fish is equal to the conductivity of the water. The difference in conductivities is commonly referred to as "mismatch." By normalizing or standardizing the power curve, a constant transfer of power density ($\mu W/cm^3$) can be achieved (Kolz and Reynolds 1989) to increase power transfer to the fish in order to illicit the desired response.

A voltage goal is the voltage required to overcome the mismatch between water conductivity and fish conductivity. Data collected from the LR-24 backpack electroshocker's internal volt meter was used to generate a peak voltage goal chart (Table 1) based on water conductivity observed in the lower Kings River downstream of Pine Flat Dam. This chart was used to guide shocker voltage settings at each site during the fall 2016 population survey. It was also determined during the testing period that a Duty Cycle of 20% and a Frequency of 30Hz resulted in a high capture rate and quick recovery when compared to previous settings.

Table 1: Voltage Goals (Kolz and Reynolds 1989)

Peak Voltage Goal	
Conductivity	**V goal**
10	1892
20	1032
30	745
40	602
50	516
60	459
70	418
80	387
90	363
100	344
110	328
120	315
130	304
140	295
150	287
170	273
200	258
250	241
300	229
400	215
600	201
800	194

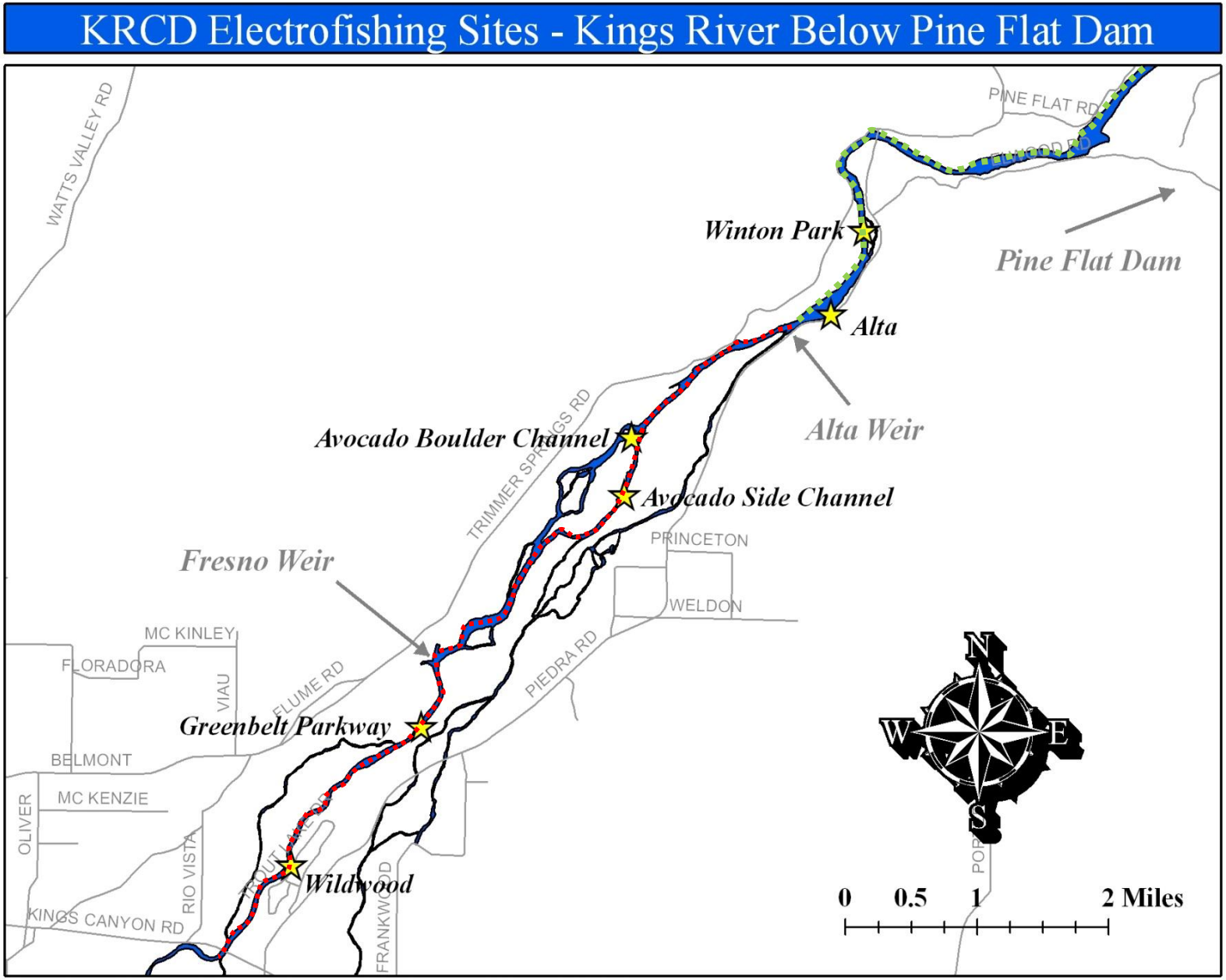

Figure 1: Electrofishing Survey Site Map. Green areas indicate the Put and Take management area and red areas indicate the Catch and Release management area.

Electrofishing was conducted using five to seven three person fishing teams and one or two data processing teams. Volunteers and staff from KRCD, KRWA, CDFW, Kings River Conservancy, California Department of Water Resources, People's Irrigation District, Fresno State University, Reedley College, Fresno Fly Fishers, Kaweah Fly Fishers and the general public participated in the surveys.

Each fishing crew consisted of backpack electrofisher operators, netters and bucketers. Data processing teams consisted of one data recorder and one to two biologists. In the field, each fish was identified to the lowest practical taxon, weighed to the nearest tenth of a gram, and total length measured to the nearest 1mm, with the exception of rainbow trout which were measured to fork length and photographed. Scale samples were taken from each rainbow trout just behind the dorsal fin for aging and all rainbow trout bearing adipose fins had blood drawn for diploid/triploid identification. Rainbow trout found to have clipped adipose fins or triploid blood samples were treated as a separate species; trout considered to be stream reared with diploid blood samples were classified as *wild.* After data collection was complete, captured fish were released outside of the netted survey reach. A minimum 30-minute hiatus was taken between passes. Biological data was manually recorded on data sheets printed on waterproof paper. Raw capture data was later entered into an Excel spreadsheet before importation into the MicroFish 3.0 program (Van Deventer 2007). MicroFish generated the Total Catch and Population Estimate (Maximum Likelihood) tables used for data analysis. Biomass, density and population estimates were also calculated using the MicroFish software.

Catch-Per-Unit-of-Effort

Catch-per-unit-of-effort (CPUE) is a measure of relative abundance used in fisheries management to assess changes in population abundance over time (Reynolds 1996; Chipps and Garvey 2007). This index is mathematically defined as:

$$C/f = N$$

where C is the number of each species caught, f is the amount of effort used, and N is the species catch rate (number per hour of effort). For this survey, effort (f) was measured in time (seconds) that each shocker was energized during each survey pass. Each backpack electrofisher was

equipped with a timer that recorded the number of seconds in operation. The total time was converted to hours and the resulting CPUE was translated to "fish per hour." CPUE was calculated for each species sampled.

Fish-Per-Hectare

Fish-per-hectare (fish*ha-1) is a population density estimate which takes the maximum likelihood of occurrence from each site and divides it by the surface area of the sample reach. A hectare is equivalent to 10,000 square meters or approximately 2.5 acres. This estimate accounts for both the length and width of each site.

Condition Factor

Condition Factor (K-factor) is an index of an individual salmonid's body fitness and condition. The score is based upon a mathematical formula (Fulton1902) which utilizes length (mm) and weight (g) parameters to determine the fitness of individuals within a population.

$$K = (W/L^3) \times 100{,}000$$

The condition factor assumes that heavier fish of a given length are in better condition (Bolger and Connolly 1989; Tasaduq et al. 2011). A fish is said to be in better condition when the value of a K-factor is more than 1.00 and in worse condition than an average individual of the same length, when its value is less than 1.00 (Tasaduq et al. 2011).

Wild Trout Density

The number of wild trout per mile is extrapolated from the annual population estimate. This estimate is an index used to monitor changes in wild trout density from year to year. The wild trout per mile estimate is based on population data collected from the six survey sites located within the 12.5 mile river reach, which extends from Pine Flat Dam to the Highway 180 Bridge. The six sites total 1,800 feet or 2.7% of the reach length. In order to provide a representative depiction of the fishery two sites totaling 600 feet (300 ft. each) are surveyed within each of the three management zones. This is further broken down to 2.3% of the Put and

Take zone, 2.9% of the Catch and Release zone and 3.3% of the Catch and Release zone below Fresno Weir.

Results

A total of 5,942 fishes were collected during the fall 2016 population survey. Of those, 5,661 were entered into the MicroFish software program for analysis. We were unable to obtain length/weight data for the remaining 281 fishes. The numbers reflected in this report will be those produced by the MicroFish software with the exception of CPUE which will reflect the total catch. Species collected included; Sacramento sucker *Catostomus occidentalis*, California roach *Hesperoluecus symettricus*, Sacramento pikeminnow *Ptycheilus grandis*, sculpin *Cottus sp.*, lamprey *Lampetra spp*, three-spined stickleback *Gasterosteus aculeatus*, bass *Micropterus punctulatus*, mosquitofish *Gambusia affinis*, bluegill *Lepomis macrochirus*, wild rainbow trout and a hatchery reared rainbow trout *Oncorhynchus mykiss*. Although more than one species of sculpin, lamprey, bass, etc. may have been collected during the survey they have been classified within their respective genus for the purpose of this report. The total catch by taxa and site is presented in Table 2. Population estimates by taxa and site are summarized in Table 3. Percent composition is summarized by species in Table 4 and 95% confidence intervals for the population estimates by taxa and survey site are summarized in Appendix A (Table A).

Table 2: Total catch by species and survey site

Total Catch by Species November 2016							
	Winton	Alta	Avo Boulder	Avo Side	Greenbelt	Wildwood	Total
Rainbow Trout	0	0	2	4	0	1	7
Hatchery Trout	2	0	8	2	0	0	12
Bass	0	0	0	0	15	1	16
Bluegill	0	0	0	0	3	0	3
California Roach	11	327	359	167	89	580	1533
Lamprey sp.	3	130	26	138	2	0	299
Mosquitofish	0	15	0	0	1	16	32
Sacramento Pikeminnow	52	72	175	10	40	44	393
Sacramento Sucker	539	391	364	207	488	556	2545
Sculpin sp.	210	27	24	4	37	1	303
Three-spined Stickleback	92	78	95	129	6	118	518
Site Total	**909**	**1040**	**1053**	**661**	**681**	**1317**	**5661**

Catch-Per-Unit-of-Effort

The CPUE for each taxon is summarized by site in Table 5. A comparison of CPUE values from 2007 to 2016 is summarized in Appendix B.

Table 3: Population estimate by maximum likelyhood

Population Estimate (maximum likelihood) November 2016						
	Winton	Alta	Avo Boulder	Avo Side	Greenbelt	Wildwood
Rainbow Trout	0	0	2	4	0	1
Hatchery Trout	2	0	8	2	0	0
Bass	0	0	0	0	15	1
Bluegill	0	0	0	0	3	0
California Roach	11	376	491	283	114	922
Lamprey sp.	3	165	35	386	2	0
Mosquitofish	0	17	0	0	1	21
Sacramento Pikeminnow	78	78	232	10	56	66
Sacramento Sucker	844	556	1034	291	574	827
Sculpin sp.	230	30	26	4	37	1
Three-spined Stickleback	158	117	142	559	6	175
Site Total	1326	1339	1970	1539	808	2014

Table 4: Total catch % by species

Total Catch (% by species) November 2016						
	Winton	Alta	Avo Boulder	Avo Side	Greenbelt	Wildwood
Rainbow Trout	0.0%	0.0%	28.6%	57.1%	0.0%	14.3%
Hatchery Trout	16.7%	0.0%	66.7%	16.7%	0.0%	0.0%
Bass	0.0%	0.0%	0.0%	0.0%	93.8%	6.3%
Bluegill	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%
California Roach	0.7%	21.3%	23.4%	10.9%	5.8%	37.8%
Lamprey sp.	1.0%	43.5%	8.7%	46.2%	0.7%	0.0%
Mosquitofish	0.0%	46.9%	0.0%	0.0%	3.1%	50.0%
Sacramento Pikeminnow	13.2%	18.3%	44.5%	2.5%	10.2%	11.2%
Sacramento Sucker	21.2%	15.4%	14.3%	8.1%	19.2%	21.8%
Sculpin sp.	69.3%	8.9%	7.9%	1.3%	12.2%	0.3%
Three-spined Stickleback	17.8%	15.1%	18.3%	24.9%	1.2%	22.8%

Table 5: Catch per unit of effort

CPUE (fish/hr) 2016						
	Winton	Alta	Avo Boulder	Avo Side	Greenbelt	Wildwood
Rainbow Trout	0.00	0.00	0.30	0.78	0.00	0.17
Hatchery Trout	0.27	0.00	1.20	0.39	0.00	0.00
Bass	0.00	0.00	0.00	0.00	2.41	0.17
Bluegill	0.00	0.00	0.00	0.00	0.16	0.00
California Roach	1.51	61.70	54.12	32.36	14.29	95.87
Green Sunfish	0.00	0.00	0.00	0.00	0.32	0.00
Lamprey sp.	0.41	24.53	3.90	26.74	0.32	0.00
Mosquitofish	0.00	2.83	0.00	0.00	0.16	2.64
Sacramento Pikeminnow	7.12	13.58	26.69	1.94	6.42	7.26
Sacramento Sucker	73.84	73.77	95.80	40.12	78.33	91.75
Sculpin sp.	28.77	5.09	3.60	0.78	5.94	0.17
Three-spined Stickleback	12.60	14.72	14.24	25.00	0.96	19.47

Site 1 – Winton Park

Multiple-pass depletion sampling yielded 909 fishes representing seven taxa. Sacramento sucker accounted for 59.3%, sculpin accounted for 23.1%, and three-spined stickleback accounted for 10.1% of the catch. Sacramento pikeminnow, California roach, lamprey, and hatchery rainbow trout accounted for the rest of the catch. Sacramento sucker (6,804g), sculpin (1,936g) and hatchery rainbow trout (720g), represented the majority of the biomass collected.

The estimated population density for this site is 3,584 fish*ha^{-1}. By species, this represents 2,281 Sacramento sucker, 622 sculpin, 427 three-spine stickleback, 211 Sacramento pikeminnow, 30 California roach, 8 lamprey and 5 hatchery rainbow trout.

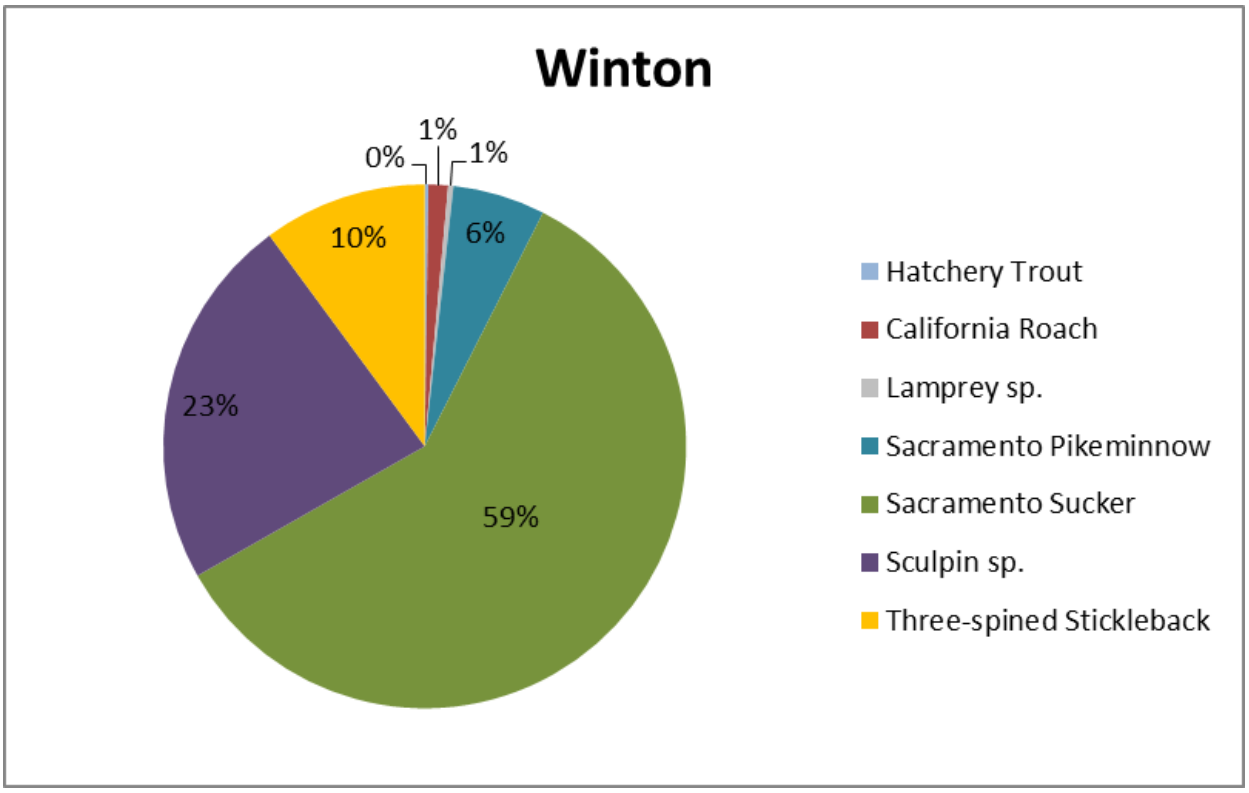

Figure 2: Species composition for Winton survey reach 2016

Site 2 – Alta

Multiple-pass depletion sampling yielded 1,040 fishes representing seven taxa. Sacramento sucker accounted for 37.6%, California roach accounted for 31.4%, and lamprey accounted for 12.5% of the catch. Three-spined stickleback, Sacramento pikeminnow, sculpin, and mosquitofish accounted for the rest of the catch. Sacramento sucker (1915g), California roach (491g), and Sacramento pikeminnow (326g) represented the majority of the biomass collected.

The estimated population density for this site is 7,439 fish*ha^{-1}. By species, this represents 3,089 Sacramento suckers, 2,089 California roach, 917 lamprey, 650 three-spined stickleback, 433 Sacramento pikeminnow, 167 sculpin, and 94 mosquitofish.

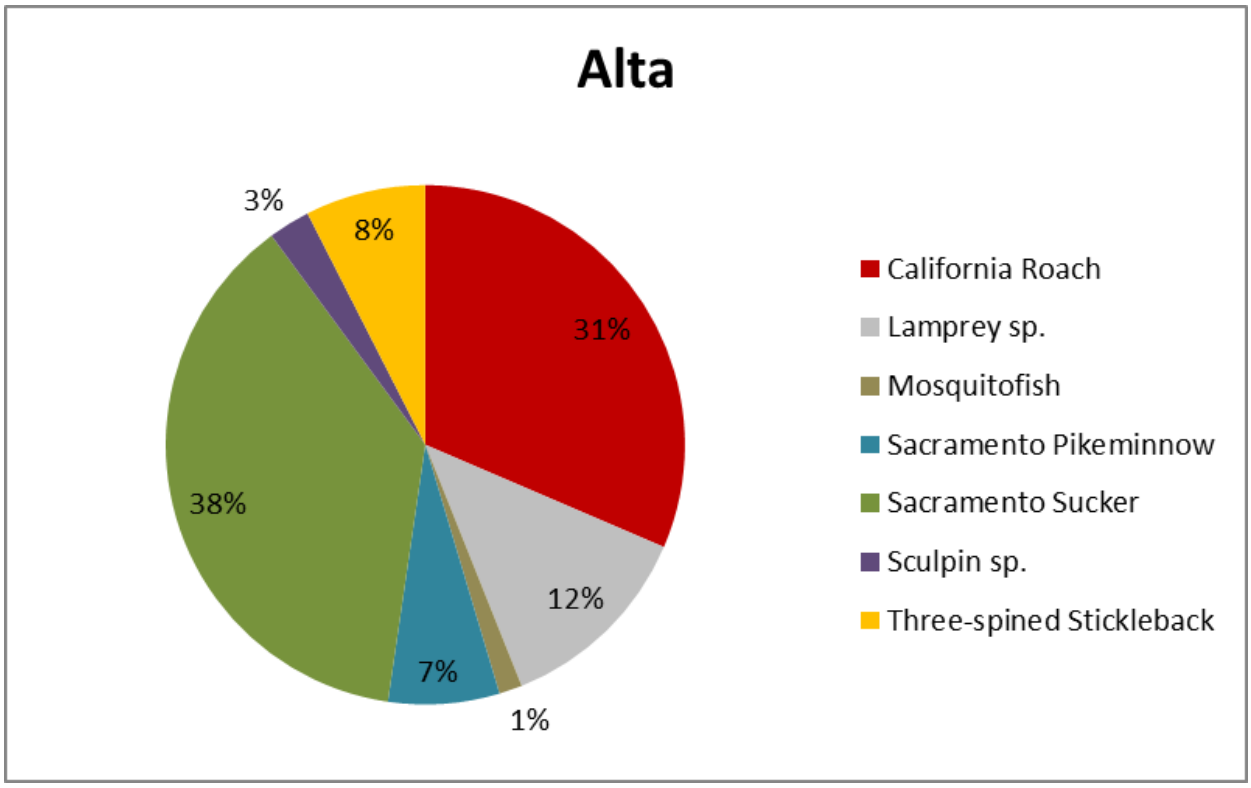

Figure 3: Species composition for Alta survey reach 2016

Site 3 – Avocado Boulder Project

Multiple-pass depletion sampling yielded 1,053 fishes representing eight taxa. Sacramento sucker accounted for 34.6%, California roach accounted for 34.1%, and Sacramento pikeminnow accounted for 16.6% of the catch. Three-spined stickleback, lamprey, sculpin, hatchery rainbow trout, and wild rainbow trout accounted for the rest of the catch. Sacramento sucker (16,838g), Sacramento pikeminnow (2,741g), and hatchery rainbow trout (2,723g) represented the majority of the biomass collected.

The estimated population density for this site is 13,088 fish*ha^{-1}. By species, this represents 6,869 Sacramento sucker, 3,262 California roach, 1,541 Sacramento pikeminnow, 943 three-spined stickleback, 233 lamprey, 173 sculpin, 53 hatchery rainbow trout, and 14 wild rainbow trout.

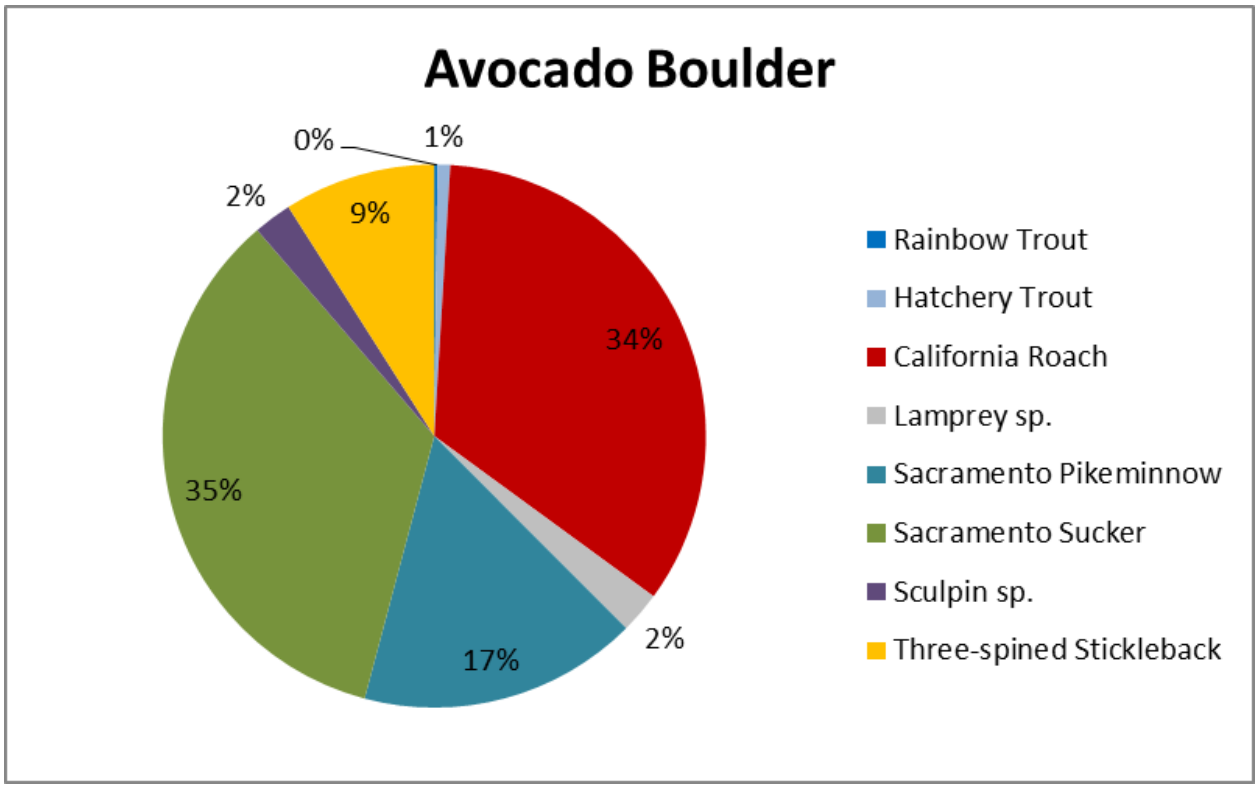

Figure 4: Species composition for Avocado Boulder survey reach 2016

Site 4 – Avocado Side Channel

Multiple-pass depletion sampling yielded 661 fishes representing eight taxa. Sacramento sucker accounted for 31.3% California roach accounted for 25.3%, and lamprey accounted for 20.9% of the catch. Three-spined stickleback, Sacramento pikeminnow, wild rainbow trout, sculpin, and bass accounted for the rest of the catch. Sacramento sucker (5,437g), California roach (672g), and lamprey (652g) represented the majority of the biomass collected.

The estimated population density for this site is 9,294 fish*ha^{-1}. By species, this represents 3,376 three-spined stickleback, 2,331 lamprey, 1,757 Sacramento sucker, 1,709 California roach, 60 Sacramento pikeminnow, 25 wild rainbow trout, 24 sculpin and 12 hatchery rainbow trout.

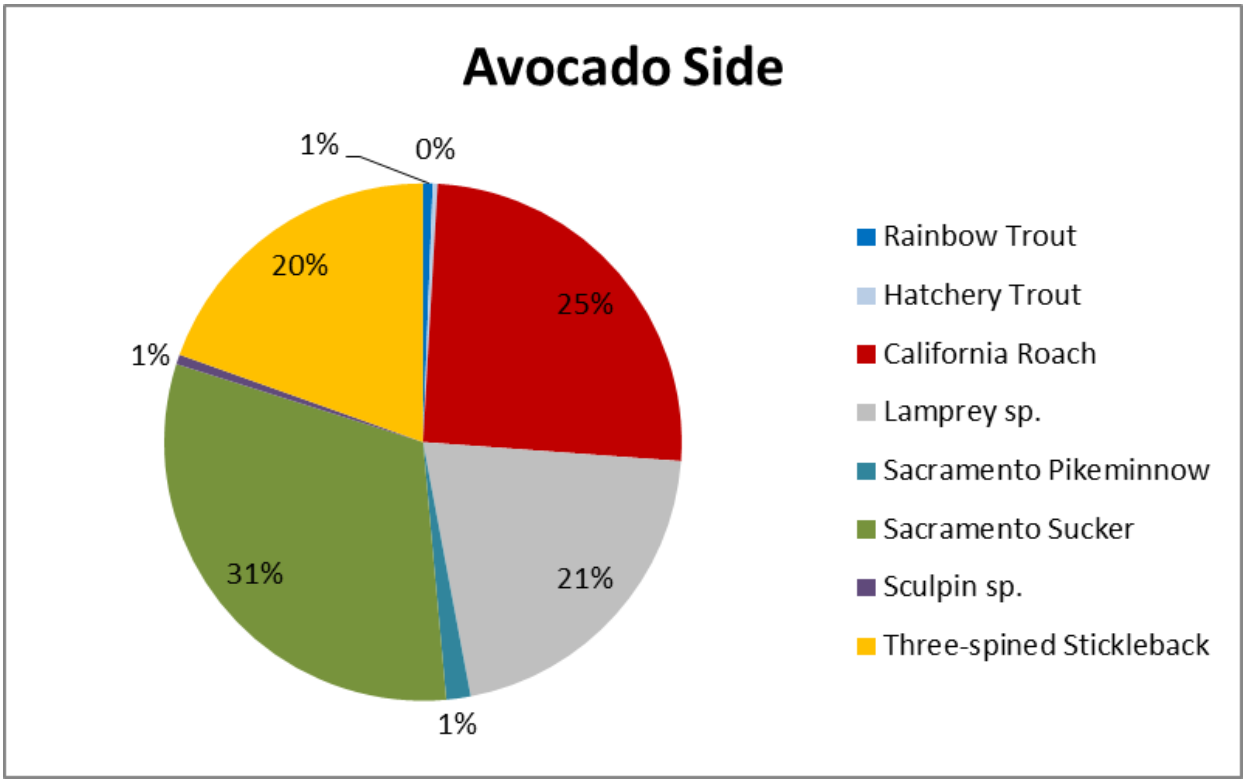

Figure 5: Species composition for Avocado Side Channel survey reach 2016

Site 5 – Greenbelt Parkway

Multiple-pass depletion sampling yielded 681 fishes representing nine taxa. Sacramento sucker accounted for 71.1%, California roach accounted for 13.1%, and Sacramento pikeminnow accounted for 5.9% of the catch. Sculpin, bass, three-spined stickleback, bluegill, lamprey and mosquitofish accounted for the rest of the catch. Sacramento sucker (2,342g), sculpin (348g) and California roach (272g) represented the majority of the biomass collected.

The estimated population density for this site is 3,078 fish*ha^{-1}. By species, this represents 2,187 Sacramento sucker, 434 California roach, 213 Sacramento pikeminnow, 141, 57 bass, 23 three-spined stickleback, 11 bluegill, 8 lamprey and 4 mosquitofish.

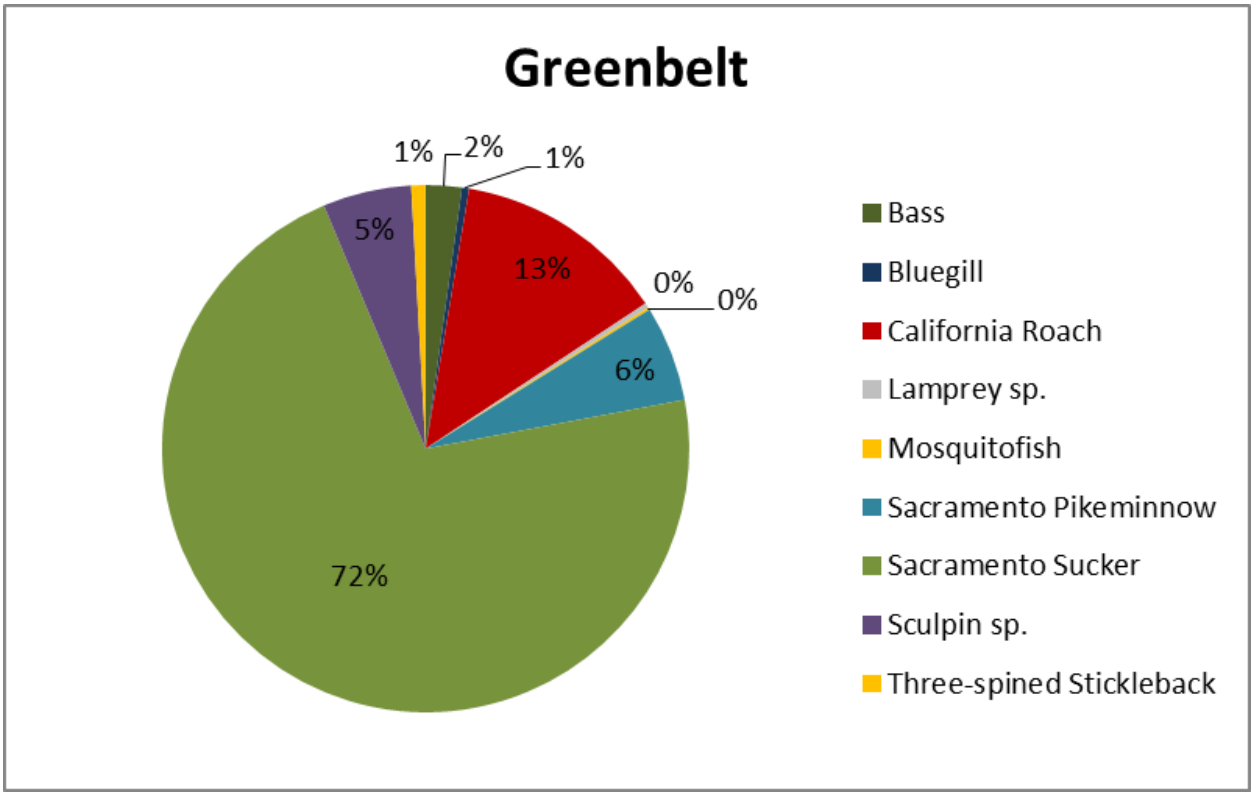

Figure 6: Species composition for the Greenbelt survey reach 2016

Site 6 – Wildwood

Multiple-pass depletion sampling yielded 1,317 fishes representing eight taxa. California roach accounted for 44.0%, Sacramento sucker accounted for 42.2%, and three-spined stickleback accounted for 9.0% of the catch. Sacramento pikeminnow, mosquitofish, wild rainbow trout, bass, and sculpin accounted for the rest of the catch. Sacramento sucker (5,103g), California roach (1,468g) and wild rainbow trout (297g) represented the majority of the biomass collected.

The estimated population density for this site is 7,128 fish*ha^{-1}. By species, this represents 3,263 California roach, 2,927 Sacramento sucker, 619 three-spined stickleback, 234 Sacramento pikeminnow, 74 mosquitofish, 4 wild rainbow trout, 4 hatchery rainbow trout and 3 sculpin

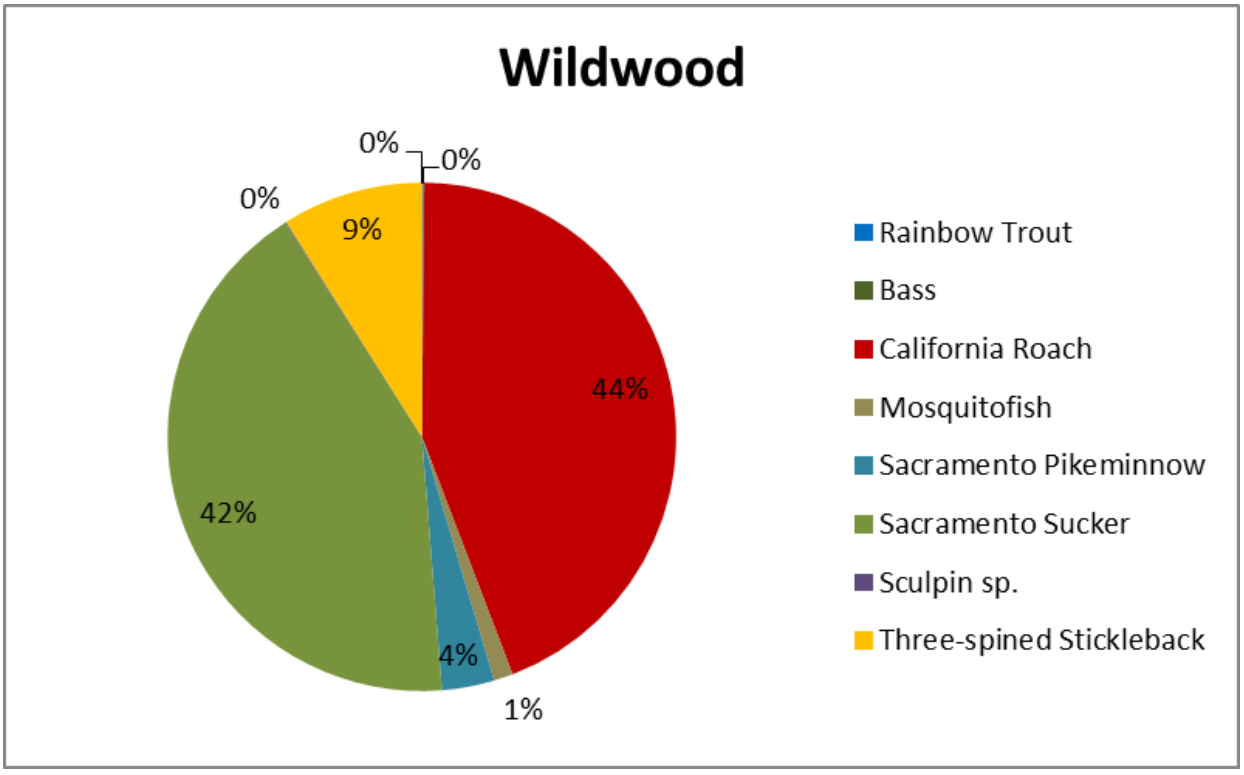

Figure 7: Species composition for the Wildwood survey reach 2016

Species Composition

Species composition reflects a combination of environmental and historical events at a site; hence, changes in species composition can provide a sensitive measure of ecologically relevant changes in the environment (Philippi et al. 1998). Altogether eleven taxa of fish were collected during the 2016 survey (Figure 8). Comparative charts of species composition from 2010 – 2016 are presented in Appendix C.

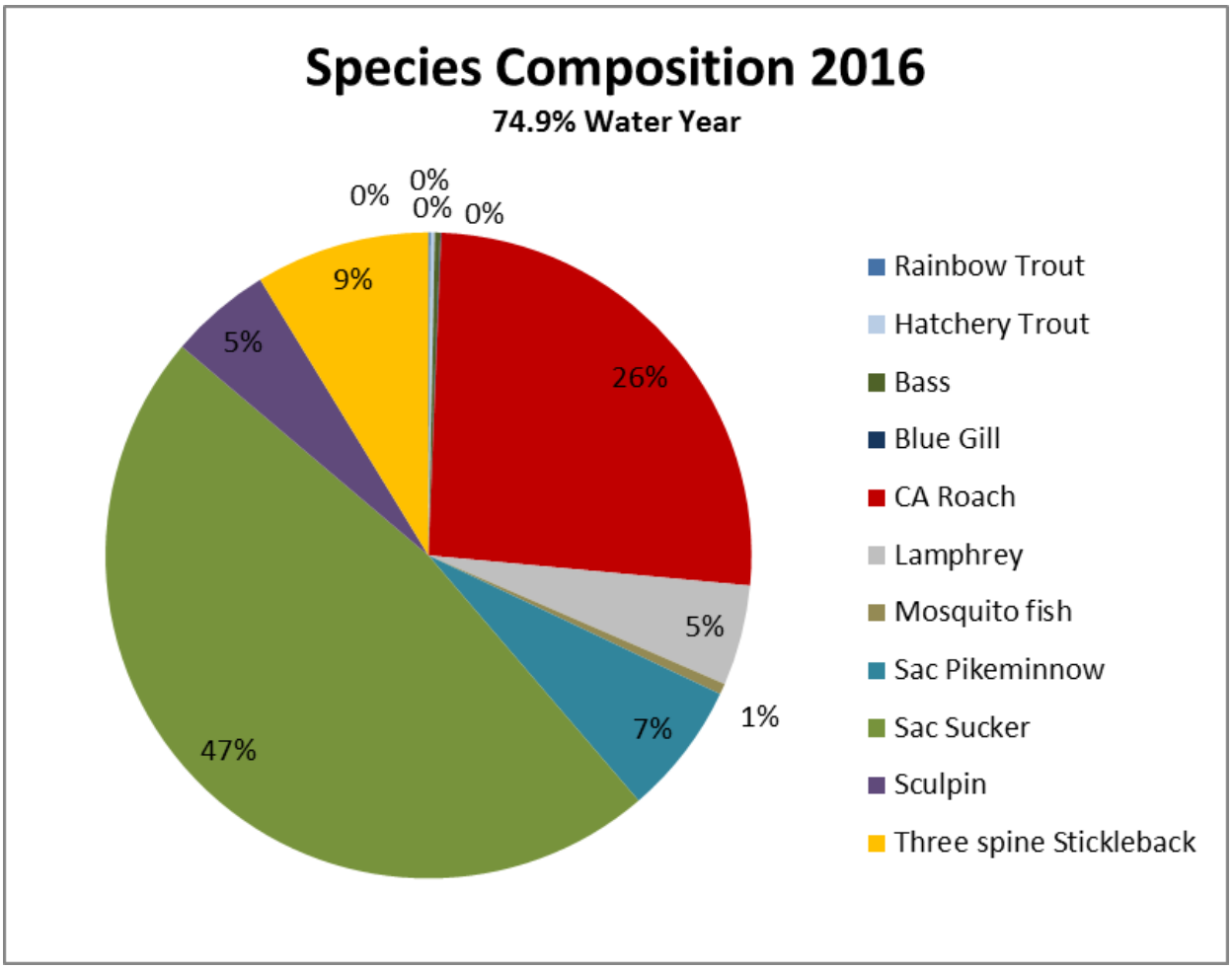

Figure 8: Species composition of total catch 2016

Wild Trout Density

Six sites were sampled over six days resulting in the capture of seven wild trout during the 2016 survey. This roughly translates to 123 wild trout per mile in similar reaches of the fishery. Historic wild trout density estimates dating back to 1983 are summarized in Figure 3.

Biomass

Biomass represents the weight of the fish population. The biomass for a given year equals the biomass of the previous year plus recruitment and growth minus harvest and mortality (Chipps and Garvey 2007). In 2016, the total biomass collected was 56,364.1g (123.9 lbs.). Sacramento sucker accounted for 68% (38,438.7g; 84.4 lbs.), California roach accounted for 9% (4,801.8g; 10.6 lbs.) and hatchery rainbow trout accounted for 7% (3,873.0g; 8.5 lbs.). Sacramento pikeminnow, sculpin, lamprey, three-spine stickleback, bass, bluegill and mosquito fish accounted for the remaining 16% (9,250.6g; 20.38 lbs.). Biomass results for the 2016 survey are summarized by site in Table 7.

Table 6: Biomass, weight in pounds

Total Weight (lbs) November 2016							
	Winton	**Alta**	**Avo Boulder**	**Avo Side**	**Greenbelt**	**Wildwood**	**Total**
Rainbow Trout	0.00	0.00	0.74	0.62	0.00	0.66	2.02
Hatchery Trout	1.59	0.00	6.00	0.90	0.00	0.00	8.49
Bass	0.00	0.00	0.00	0.00	0.48	0.05	0.53
Bluegill	0.00	0.00	0.00	0.00	0.13	0.00	0.13
California Roach	0.03	1.10	4.20	1.50	0.60	3.20	10.63
Lamprey sp.	0.03	0.68	0.26	1.40	0.02	0.00	2.39
Mosquitofish	0.00	<0.01	0.00	<0.01	<0.01	0.01	0.01
Sacramento Pikeminnow	0.33	0.72	6.00	0.25	0.41	0.49	8.20
Sacramento Sucker	15.00	4.20	37.00	12.00	5.20	11.00	84.40
Sculpin sp.	4.30	0.33	0.55	0.08	0.77	0.04	6.07
Three-spined Stickleback	0.19	0.06	0.18	0.36	<0.01	0.24	1.03
Site Total	**21.47**	**7.09**	**54.93**	**17.11**	**7.61**	**15.69**	**123.90**
Biomass %	**17.3%**	**5.7%**	**44.3%**	**13.8%**	**6.1%**	**12.7%**	**100.0%**

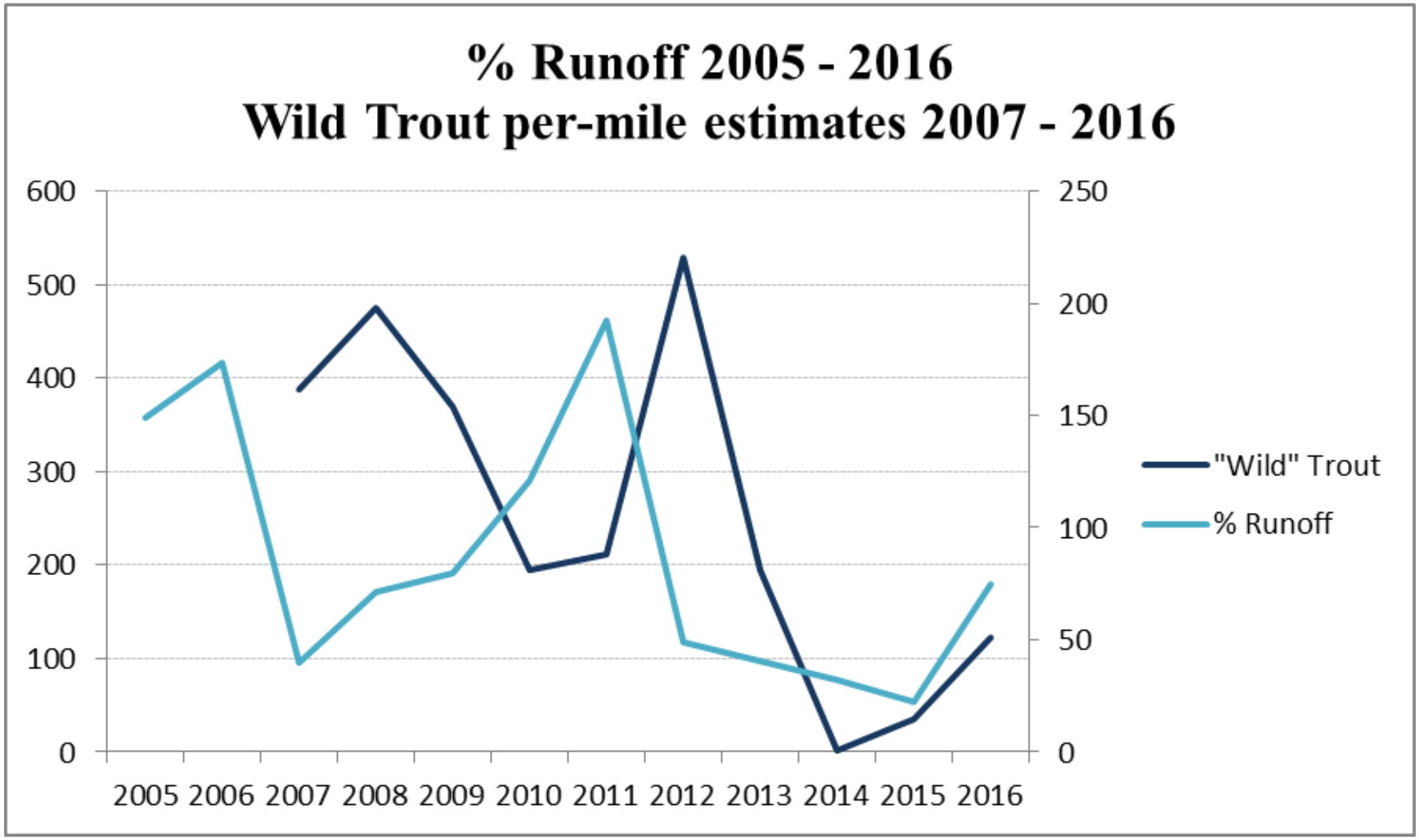

Figure 3: Estimated number of "wild" trout per mile in the Kings River between Pine Flat Dam and the Highway 180 Bridge, Fresno County. Density is extrapolated from the number of wild trout collected from six sample sites located within the reach of the Kings River between Pine Flat Dam and the Highway 180 Bridge.

Length

The mean fork length for wild rainbow trout collected during the 2016 survey was 21.7 cm (approx. 8.5 inches). The mean fork length for wild rainbow trout collected between 2007 and 2015 (n = 136) is 18.7cm (approx. 7.4 inches).

Condition Factor (K)

All of the wild trout collected in 2016 were found to be in good condition (Table 7). The condition factor for these trout ranged from 0.73 (fair) to 1.3 (very good).

Age

Scale samples from the seven wild rainbow trout collected in 2016 were used to estimate trout age based on counts of annuli and circuli. The mean age of wild trout captured in 2016 was 2.2 (1 – 3) years. In eight years no wild rainbow trout < 1yr. of age have been collected and only one trout > 4yrs. of age has been recorded. The mean age of wild rainbow trout caught since 2008 is 2 years. A depiction of the age/length frequency distribution 2016 can be referenced in Figure 11.

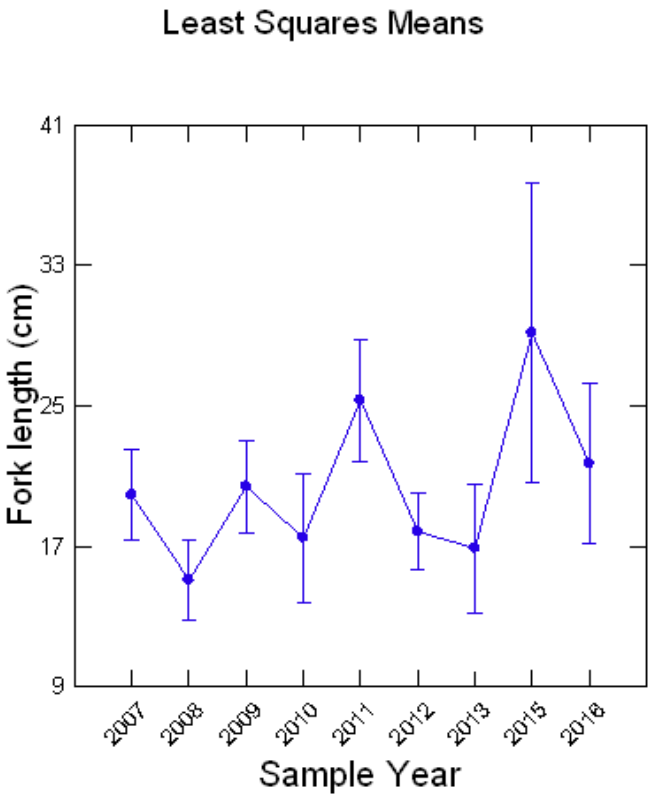

Figure 9: Changes in mean fork length 2007 - 2016

Table 7: Wild rainbow trout age class and condition factor (K-factor) where 1 is equal to good

SITE	AGE	K-FACTOR
Avocado Boulder	3	1.2
Avocado Side	2+	0.73
Avocado Side	2+	1.3
Avocado Side	2	1.2
Avocado Side	1+	1.3
Wildwood	3+	1.2

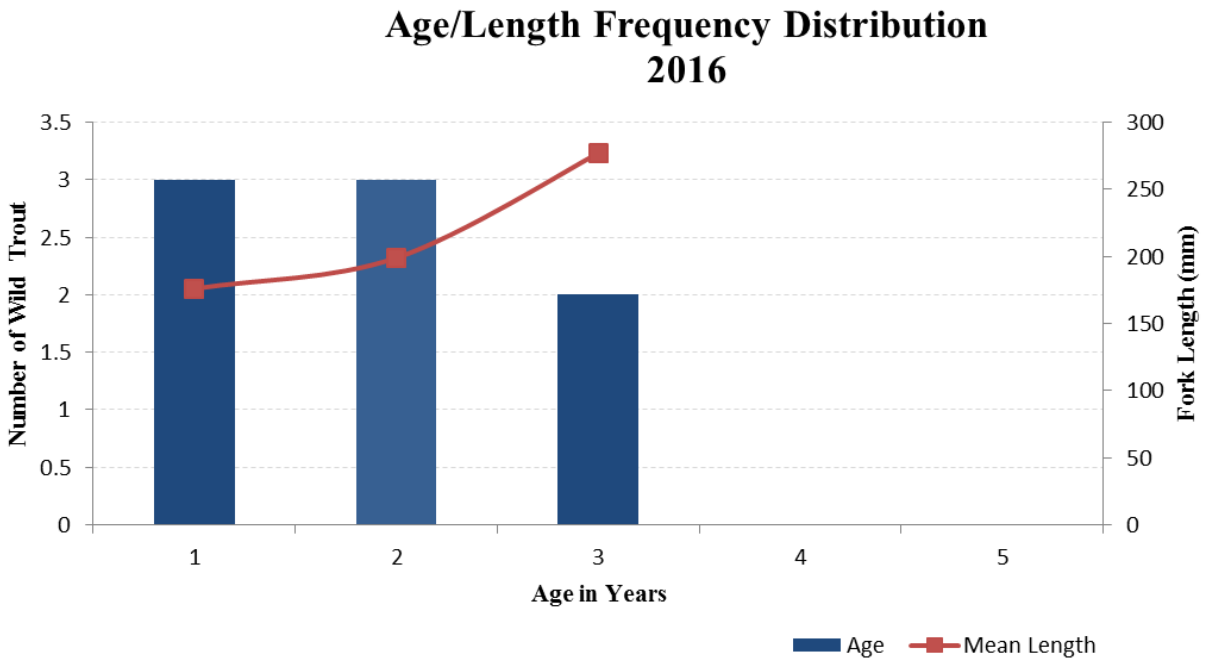

Figure 10: Average age/length frequency distribution for wild rainbow trout 2016

Conclusion

This year marked the ninth year of multiple pass depletion sampling since the FMP returned to triple-pass depletion in 2007. In addition, this year marked the fifth year that the FMP utilized deliberate voltage adjustment by site for the LR-24 units in concurrence with water conductivity. It is not certain how this may have influenced 2012 – 2016 catch efficiency.

A total of 5,942 fishes were collected during the 2016 survey. Of those 5,661 were analyzed with Microfish software. Decreases from 2015 were documented in the abundance of Sacramento pikeminnow, bass and mosquitofish. The most significant increases in abundance were seen in three-spined stickleback (325%), Sacramento sucker (91.5%) and lamprey (58%). It should be noted that bluegill increased by >1,000% from 0-3, hatchery trout by >1,000% from 1-12 and wild rainbow trout by 250% from 2-7 however significant; these quantities are quantifiably minimal when compared to those listed above.

Standing stock was dominated by Sacramento sucker, California roach and three-spined stickleback which accounted for 82% of the total catch, Sacramento sucker accounted for 47%,

California roach 26%, and three-spined stickleback for 9%. In all, fishes native to the Kings River made up 99% of fish captured.

This year's survey produced twelve hatchery trout and seven wild rainbow trout. This translated to 123 wild trout per mile. The condition factor of the wild trout captured during the 2016 survey was good, indicating that the trout were in good health and not resource limited. Wild trout ages ranged from one to three indicating that a small portion of wild trout were able to successfully hold over during drought years.

Since our return to triple-pass-depletion in 2007 we have yet to discover any affirmative correlations linking observed environmental variables to species composition or abundance. There appears to be a congruent 1 to 2 year delay in wild trout population response to increase/decrease in percent runoff (water year.). This observational relationship is not statistically significant (Spearman's Rho: df = 3.03, 3.02, R = 0.63) however the 10 year sample size is small. A significant correlation between wild trout populations and percent runoff could suggest that annual climatic conditions in the Kings River watershed have a greater effect on wild trout populations than anthropogenic factors alone. New approaches to analyzing this data will be examined in the coming year. It is unlikely that variations in species composition can be attributed to any one cause and far more likely that a combination of environmental and anthropogenic factors influence the fishery. The Kings River Fisheries Management Program will continue comprehensive monitoring and investigation of environmental variables within the tailwater fishery; endeavoring to better understand the factors driving population dynamics and variations in species richness within the river.

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Appendix A

Table A: 95% confidence interval population estimates for each species summarized by site. Population estimates were generated using Microfish 3.0

95% Confidence Interval (Adjust to lower CI) November 2016						
	Winton	**Alta**	**Avo Boulder**	**Avo Side**	**Greenbelt**	**Wildwood**
Rainbow Trout	0-0	0-0	2-2	4-6	0-0	1-1
Hatchery Trout	2-2	0-0	8-9	2-2	0-0	0-0
Bass	0-0	0-0	0-0	0-0	15-17	1-1
Bluegill	0-0	0-0	0-0	0-0	3-8	0-0
California Roach	11-12	347-405	414-568	167-399	89-143	748-1096
Lamprey sp.	3-6	132-198	26-56	138-819	2-7	0-0
Mosquitofish	0-0	15-24	0-0	0-0	1-1	16-37
Sacramento Pikeminnow	78-78	72-87	185-279	10-11	40-86	66-66
Sacramento Sucker	685-1003	462-650	836-1232	225-357	532-616	693-961
Sculpin sp.	214-246	27-38	24-32	4-5	37-39	1-1
Three-spined Stickleback	92-249	78-170	142-142	129-1,750	6-10	118-237

Appendix B

Table B – I: Catch per Unit of Effort by species; 2007 – 2016. Note: Nine sites were sampled during the 2007 survey and eight sites were sampled during the 2010 survey. Data collected from the additional sites were not used in this comparison.

Table B: CPUE 2007

CPUE (fish/hr) 2007						
	Winton	**Alta**	**Avo Boulder**	**Avo Side**	**Greenbelt**	**Wildwood**
Rainbow Trout	0.9	0.4	1.1	0..0	0.3	0.0
Hatchery Trout	1.2	2.3	0.3	0.7	0.0	0.0
California Roach	0.4	0.3	2.7	3.1	16.2	7.5
Green Sunfish	0.0	0.0	0.0	0.0	0.0	0.0
Lamprey sp.	0.1	22.5	0.7	19.0	0.3	0.6
Sacramento Pikeminnow	11.9	2.2	10.1	21.8	25.6	53.6
Sacramento Sucker	41.7	50.5	52.4	34.7	32.7	44.7
Sculpin sp.	48.1	50.1	23.5	29.5	23.7	34.3
Three-spined Stickleback	0.9	3.5	0.9	2.2	0.0	1.8

Table C: CPUE 2008

CPUE (fish/hr) 2008						
	Winton	**Alta**	**Avo Boulder**	**Avo Side**	**Greenbelt**	**Wildwood**
Rainbow Trout	1.1	0.8	1.1	1.4	0.1	0.0
Hatchery Trout	0.0	0.0	0.2	0.0	0.0	0.0
California Roach	0.0	1.2	12.8	2.8	29.5	40.8
Lamprey sp.	0.3	9.4	0.8	13.2	0.3	0.0
Mosquitofish	0.0	0.4	0.0	0.0	0.0	0.0
Sacramento Pikeminnow	8.8	3.0	21.7	8.3	20.1	18.7
Sacramento Sucker	12.9	31.3	34.5	17.5	13.5	2.6
Sculpin sp.	23.7	26.6	20.2	12.5	3.8	5.7
Three-spined Stickleback	0.0	7.2	3.0	3.3	0.0	6.0
White Catfish	0.0	0.0	0.2	0.0	0.1	0.0

Table D: CPUE 2009

CPUE (fish/hr) 2009						
	Winton	**Alta**	**Avo Boulder**	**Avo Side**	**Greenbelt**	**Wildwood**
Rainbow Trout	0.9	0.1	1.3	0.3	0.0	0.0
Hatchery Trout	0.1	0.1	0.0	0.0	0.0	0.0
Bluegill	0.0	0.0	0.0	0.0	0.1	0.0
Bullhead Catfish	0.0	0.0	0.0	0.0	0.1	0.0
California Roach	0.0	1.3.7	3.4	1.0	6.0	38.9
Lamprey sp.	0.5	8.4	0.6	13.4	0.1	0.1
Largemouth Bass	0.0	0.0	0.0	0.2	0.1	0.0
Sacramento Pikeminnow	1.8	7.1	6.8	4.9	10.3	17.2
Sacramento Sucker	3.8	18.0	26.4	9.1	6.2	2.1
Sculpin sp.	35.9	40.5	27.8	18.5	9.8	5.8
Small Mouth Bass	0.0	0.0	0.0	0.0	0.2	0.0
Three-spined Stickleback	0.1	5.7	2.4	2.9	0.6	2.6
White Catfish	0.0	0.0	0.0	0.0	0.1	0.0

Table E: CPUE 2010

CPUE (fish/hr) 2010						
	Winton	**Alta**	**Avo Boulder**	**Avo Side**	**Greenbelt**	**Wildwood**
Rainbow Trout	1.1	0.0	0.0	0.7	0.0	0.0
Hatchery Trout	0.0	0.2	0.3	0.0	0.0	0.0
Brook Trout	0.1	1.0	0.0	0.2	0.0	0.0
California Roach	0.7	3.0	7.4	1.2	13.0	54.2
Lamprey sp.	0.0	8.9	1.0	6.7	0.2	0.7
Sacramento Pikeminnow	1.3	2.0	4.3	1.7	8.7	11.2
Sacramento Sucker	4.7	29.5	17.7	10.0	2.6	8.4
Sculpin sp.	51.8	42.5	28.3	22.9	14.7	11.8
Three-spined Stickleback	2.0	9.2	0.6	0.0	0.0	6.2

Table F: CPUE 2011

CPUE (fish/hr) 2011						
	Winton	**Alta**	**Avo Boulder**	**Avo Side**	**Greenbelt**	**Wildwood**
Rainbow Trout	0.0	0.6	0.6	0.7	0.0	0.0
Hatchery Trout	0.0	0.0	0.7	0.2	0.0	0.0
California Roach	0.7	1.5	2.7	5.6	4.1	28.8
Green Sunfish	0.1	0.0	0.0	0.0	0.0	0.0
Lamprey sp.	0.0	10.2	2.0	20.1	0.0	0.0
Sacramento Pikeminnow	4.0	4.7	1.1	0.5	1.9	1.1
Sacramento Sucker	7.7	20.9	8.0	9.8	2.0	10.5
Sculpin sp.	30.6	45.4	10.0	32.1	9.4	12.6
Three-spined Stickleback	1.1	8.1	1.1	0.9	0.2	0.4

Table G: CPUE 2012

CPUE (fish/hr) 2012						
	Winton	**Alta**	**Avo Boulder**	**Avo Side**	**Greenbelt**	**Wildwood**
Rainbow Trout	0.9	0.3	1.4	0.8	0.1	0.0
Hatchery Trout	0.0	0.0	0.0	1.2	0.0	0.0
California Roach	0.0	3.4	9.3	4.0	15.2	19.9
Lamprey sp.	0.0	9.5	2.7	10.2	0.5	0.0
Mosquitofish	0.0	0.0	0.0	1.2	0.0	0.0
Sacramento Pikeminnow	0.1	1.5	19.9	22.6	8.1	17.1
Sacramento Sucker	13.0	36.5	39.4	32.6	12.2	65.1
Sculpin sp.	41.0	36.0	32.4	24.1	13.1	11.7
Three-spined Stickleback	0.0	3.3	0.7	3.2	0.5	2.6
White Catfish	0.0	0.0	0.0	0.0	0.1	0.0

Table H: CPUE 2013

CPUE (fish/hr) 2013						
	Winton	**Alta**	**Avo Boulder**	**Avo Side**	**Greenbelt**	**Wildwood**
Rainbow Trout	0.43	0.00	0.58	0.63	0.00	0.00
Hatchery Trout	0.29	0.16	0.15	0.16	0.00	0.00
Bass	0.00	0.00	0.00	0.00	0.62	0.00
California Roach	0.00	9.92	28.61	39.22	27.09	57.51
Lamprey sp.	0.43	6.30	1.02	15.94	0.37	0.00
Mosquitofish	0.00	0.16	0.00	0.00	0.00	0.00
Sacramento Pikeminnow	24.43	22.52	50.66	20.63	46.18	98.32
Sacramento Sucker	51.15	53.07	40.88	11.88	6.28	20.98
Sculpin sp.	70.83	37.64	49.34	29.38	21.67	16.84
Three-spined Stickleback	2.16	11.18	1.17	1.56	1.85	13.08
White Catfish	0.00	0.00	0.00	0.00	0.37	0.00

Table I: CPUE 2014

CPUE (fish/hr) 2014						
	Winton	**Alta**	**Avo Boulder**	**Avo Side**	**Greenbelt**	**Wildwood**
Rainbow Trout	0.00	0.00	0.00	0.00	0.00	0.00
Hatchery Trout	0.00	0.00	0.13	0.00	0.00	0.00
Bass	0.00	0.13	0.13	0.00	3.65	0.13
California Roach	2.16	12.77	25.00	11.38	24.96	60.55
Lamprey sp.	0.19	13.78	5.32	23.55	0.42	0.13
Mosquitofish	0.00	0.13	0.00	0.23	0.42	1.82
Sacramento Pikeminnow	16.14	6.19	36.17	6.60	16.41	37.89
Sacramento Sucker	10.69	11.25	19.81	7.62	4.77	10.42
Sculpin sp.	33.77	6.83	17.15	9.22	4.77	7.68
Three-spined Stickleback	3.00	27.69	4.26	6.60	0.56	8.20
White Catfish	0.19	0.00	0.27	0.23	2.10	0.00

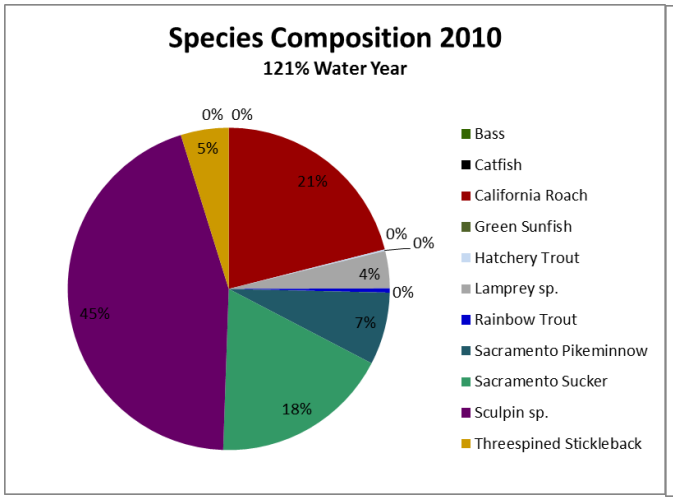
Table J: CPUE 2015

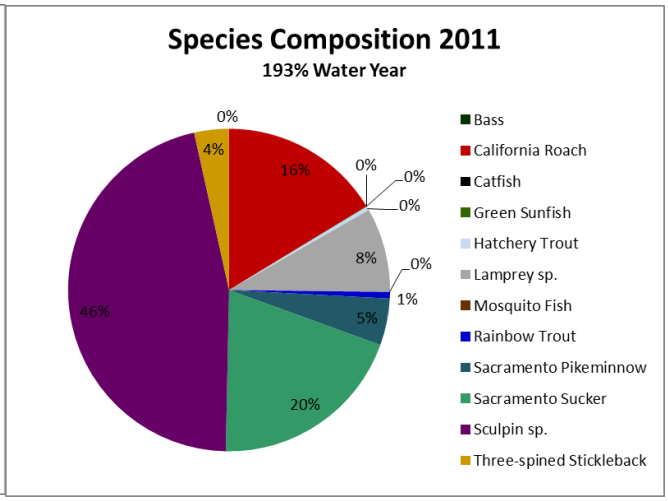
CPUE (fish/hr) 2015						
	Winton	**Alta**	**Avo Boulder**	**Avo Side**	**Greenbelt**	**Wildwood**
Rainbow Trout	0.12	0.00	0.12	0.00	0.00	0.00
Hatchery Trout	0.00	0.00	0.12	0.00	0.00	0.00
Bass	0.00	0.14	0.00	0.18	7.90	0.49
California Roach	3.92	25.17	36.05	38.86	10.49	87.59
Lamprey sp.	0.24	14.72	3.09	9.94	0.00	0.12
Mosquitofish	0.24	3.16	0.00	0.00	1.87	2.31
Sacramento Pikeminnow	14.96	6.88	24.69	29.10	15.52	19.22
Sacramento Sucker	50.12	51.03	35.68	36.83	3.45	2.80
Sculpin sp.	19.00	0.96	3.33	0.74	1.01	0.73
Three-spined Stickleback	5.70	4.26	1.73	3.68	0.00	1.09
White Catfish	0.00	0.00	0.00	0.00	0.29	0.00

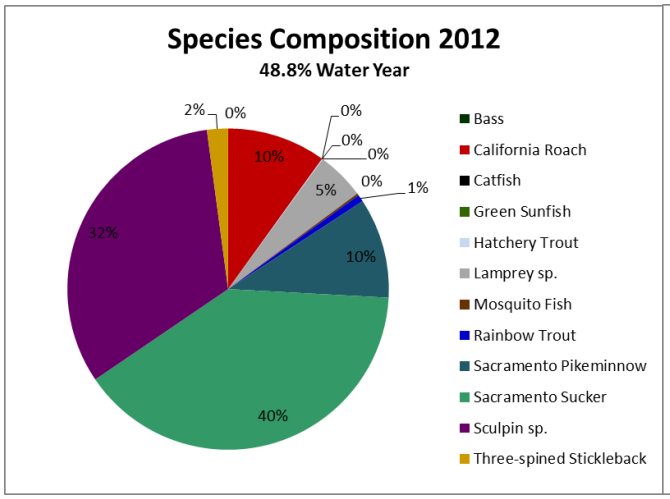
Table K: CPUE 2016

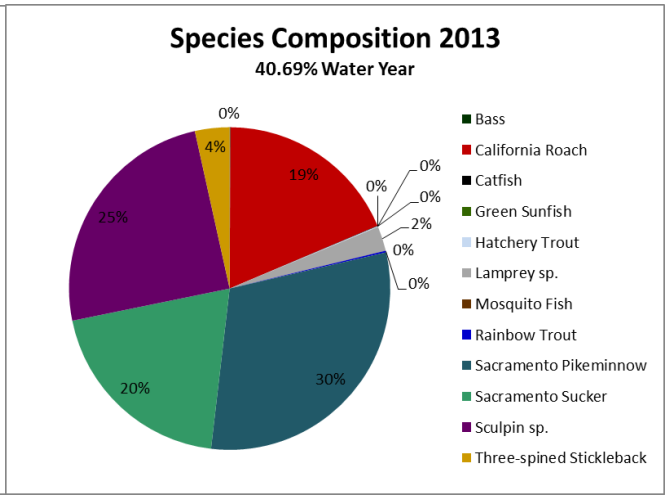
CPUE (fish/hr) 2016						
	Winton	**Alta**	**Avo Boulder**	**Avo Side**	**Greenbelt**	**Wildwood**
Rainbow Trout	0.00	0.00	0.30	0.78	0.00	0.17
Hatchery Trout	0.27	0.00	1.20	0.39	0.00	0.00
Bass	0.00	0.00	0.00	0.00	2.41	0.17
Bluegill	0.00	0.00	0.00	0.00	0.16	0.00
California Roach	1.51	61.70	54.12	32.36	14.29	95.87
Green Sunfish	0.00	0.00	0.00	0.00	0.32	0.00
Lamprey sp.	0.41	24.53	3.90	26.74	0.32	0.00
Mosquitofish	0.00	2.83	0.00	0.00	0.16	2.64
Sacramento Pikeminnow	7.12	13.58	26.69	1.94	6.42	7.26
Sacramento Sucker	73.84	73.77	95.80	40.12	78.33	91.75
Sculpin sp.	28.77	5.09	3.60	0.78	5.94	0.17
Three-spined Stickleback	12.60	14.72	14.24	25.00	0.96	19.47

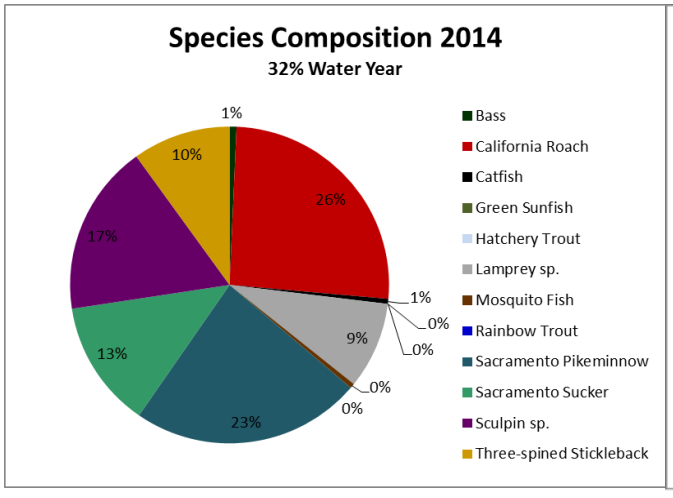
Appendix C

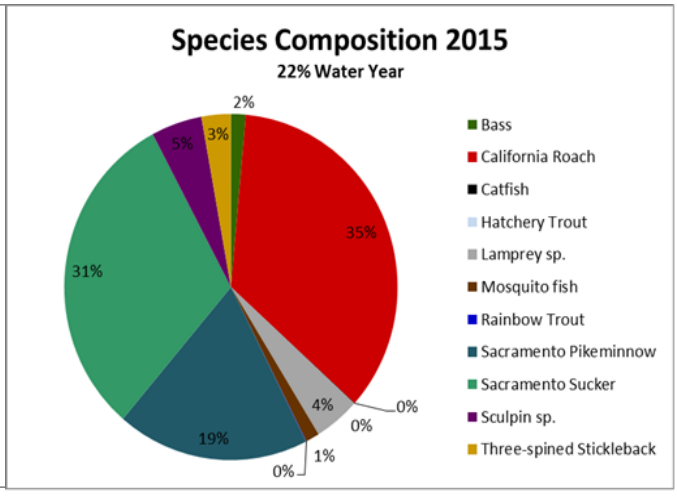

Species Composition 2010
121% Water Year
0% 0%
5%
21%
0%
0%
4%
0%
45%
7%
18%
Bass
Catfish
California Roach
Green Sunfish
Hatchery Trout
Lamprey sp.
Rainbow Trout
Sacramento Pikeminnow
Sacramento Sucker
Sculpin sp.
Threespined Stickleback

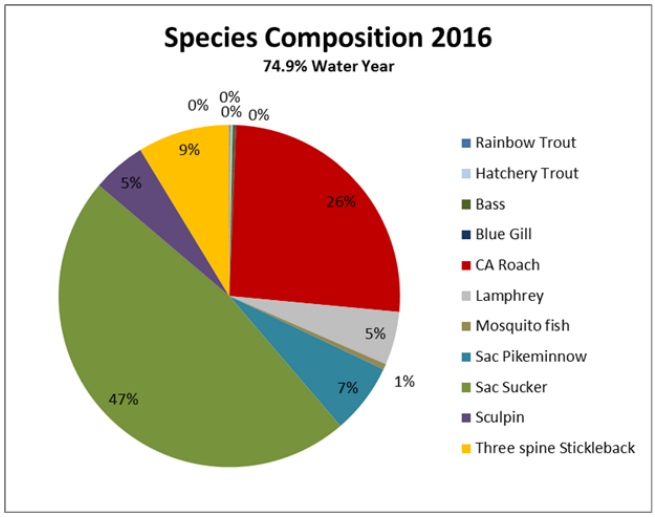

Species Composition 2011
193% Water Year
0%
4%
16%
0%
0%
0%
8%
0%
1%
46%
5%
20%
Bass
California Roach
Catfish
Green Sunfish
Hatchery Trout
Lamprey sp.
Mosquito Fish
Rainbow Trout
Sacramento Pikeminnow
Sacramento Sucker
Sculpin sp.
Three-spined Stickleback


Species Composition 2012
48.8% Water Year
2%
0%
10%
0%
0%
0%
5%
0%
1%
32%
10%
40%
Bass
California Roach
Catfish
Green Sunfish
Hatchery Trout
Lamprey sp.
Mosquito Fish
Rainbow Trout
Sacramento Pikeminnow
Sacramento Sucker
Sculpin sp.
Three-spined Stickleback


Species Composition 2013
40.69% Water Year
0%
4%
19%
0%
0%
0%
2%
0%
0%
25%
20%
30%
Bass
California Roach
Catfish
Green Sunfish
Hatchery Trout
Lamprey sp.
Mosquito Fish
Rainbow Trout
Sacramento Pikeminnow
Sacramento Sucker
Sculpin sp.
Three-spined Stickleback


Species Composition 2014
32% Water Year
1%
10%
26%
17%
1%
0%
9%
0%
13%
0%
23%
Bass
California Roach
Catfish
Green Sunfish
Hatchery Trout
Lamprey sp.
Mosquito Fish
Rainbow Trout
Sacramento Pikeminnow
Sacramento Sucker
Sculpin sp.
Three-spined Stickleback


Species Composition 2015
22% Water Year
2%
3%
5%
35%
31%
4%
0%
19%
1%
0%
Bass
California Roach
Catfish
Hatchery Trout
Lamprey sp.
Mosquito fish
Rainbow Trout
Sacramento Pikeminnow
Sacramento Sucker
Sculpin sp.
Three-spined Stickleback


Species Composition 2016
74.9% Water Year
0%
0%
0%
0%
9%
5%
26%
5%
1%
7%
47%
Rainbow Trout
Hatchery Trout
Bass
Blue Gill
CA Roach
Lamphrey
Mosquito fish
Sac Pikeminnow
Sac Sucker
Sculpin
Three spine Stickleback