Kings River, Below Pine Flat Dam: Comprehensive Report of Results from the Fall Population Electro-fishing Surveys, 2007-2019

Prepared for the Kings River Fisheries Management Program

Kings River Conservation District
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EXECUTIVE SUMMARY

Long-term annual baseline fisheries monitoring within the lower Kings River is being conducted as part of the Kings River Fisheries Management Program (KRFMP) to determine (1) the assemblage, abundance, and condition of the fish community inhabiting the lower Kings River; (2) overall fish biomass; (3) hatchery and "wild" rainbow trout abundance, distribution, and condition factor; and (4) the annual survival of rainbow trout populations. Initially this monitoring began as part of a Federal Energy Regulatory Commission (FERC) requirement for compliance with Item 4 of the Memorandum of Agreement between the California Department of Fish and Wildlife (CDFW) and the Kings River Conservation District (KRCD), for FERC Project No. 2741, but has continued as a part of the KRFMP. Different electro-fishing techniques have been used since 1983; mark-recapture surveys (1983-1989), single-pass census (1989-2006), and multi-pass depletion electro-fishing surveys (2007-2019). From 2007 through 2019 the same sites have been sampled annually when conditions allow. For multi-pass depletion sampling, block seine nets are stretched across the river at both the upstream and downstream end of each sampling reach to prevent fish from immigrating or emigrating from the survey site during sampling. Multi-pass surveys allow for a more complete assessment of the species composition and abundance found in the sample site. This data can then be used to determine trends in the populations. Surveys are conducted at the same sampling sites each year, as conditions allow, for determining trends in abundance of fish species. Surveys are completed with KRFMP agency staff and the assistance of local volunteers and college students. All data used in this analysis was compared against field notes to check for input errors or missing data and when discrepancies were found, corrections were made to the input files and the data reanalyzed. Results of the 2007 through 2019 surveys are presented here to show trends in the fishery at sample sites over the multi-pass depletion sampling period as well as the species assemblage, length-frequency of all captured fish, and condition factor of all captured trout.

Data collected during the Fall Population Electro-fishing Surveys provides a means to estimate fish populations in the Kings River between Pine Flat Dam and Highway 180. For these surveys, species were collected, identified, and enumerated, providing a snapshot of the assemblage present. Additional in situ environmental and habitat variables were not measured at the times of the surveys.

Thirteen years of multi-pass depletion surveys indicate that native fishes continue to dominate the river between Pine Flat Dam and Highway 180. On average, by abundance, they make up 99.0% of the annual collection, with introduced fish species accounting for the remainder. From 2012 through 2019 the KRFMP utilized deliberate voltage adjustment of the electro-fishers by site for concurrence with water conductivity. It is not certain how this change in voltage adjustments may have influenced catch efficiency and the interpretation of trends over time in survey results. Catch results do show that while populations of different species fluctuated over the years, the assemblage continues to be dominated by native Sacramento suckers, sculpin, and cyprinid species, and is most like the pikeminnow-hardhead-sucker assemblage described by Moyle (2002), rather than the deep-bodied fishes assemblage. While deep-bodied fishes were present, they typically comprised less than one percent of the species assemblage in most years. Trout were present but were typically no more than one percent of the species assemblage, as expected for a low elevation, low gradient, fish assemblage. Additionally, catch results indicate the successful reproduction for native species as both juvenile and adult life stages are collected for most taxa during the Fall Population Survey. An exception to this being three-spine stickleback, which typically live no more than one year, and all members of the annual cohort have reached adulthood by the time of the population survey. Non-native fish, particularly bass, are also able to successfully reproduce when conditions are suitable, as during the 2012-2016 drought when an increase in the number of young bass was observed.

For each of the species captured in the Kings River several different variables were calculated for each 300-foot sample site per year. Data imported into MicroFish 3.0 was used to generate total catch, population estimates and 95 percent confidence intervals, and total weight. Population estimates were further used to calculate in Microsoft Excel the fish-per-hectare and fish per mile. Length-weight regression analysis and Fulton's condition factor were both used to determine the overall health of all trout captured during the fall population electro-fishing surveys. For most species only population estimates per site, fish per mile per site, and lengths of captured fish are summarized below. For trout condition information is also provided. Fish per hectare per site and biomass per site is provided in the Results and Discussion section of this report.

Sacramento suckers dominate in population surveys for most years. While the population fluctuates over time, this is not uncommon as single cohorts can at times dominate the age structure of the population. Population estimates per site ranged from 14 (95% CI, lower CI adjusted, 13-19) to 1,034 (95% CI, lower CI adjusted, 836-1,232) fish, and estimated fish per mile per site ranged from 246 to 18,198. Lengths of captured fish ranged from 1 to 34 inches, with 76% of Sacramento suckers smaller than 5 inches.

Sculpin make up a major component of the fish population in the Kings River and have been the dominant species in some years of the population survey. The population did experience a decline during the 2012-2016 drought but rebounded in later years. Population estimates per site ranged from 1 (95% CI, lower CI adjusted, 1-1) to 877 (95% CI, lower CI adjusted, 812-942) fish, and estimated fish per mile per site ranged from 18 to 15,435. Lengths of captured fish ranged from 1 to 7 inches, with 94% of sculpin smaller than 4 inches.

California roach and Sacramento pikeminnow are the primary cyprinids represented in the Kings River. A single hardhead was captured over 13 years of sampling but may be underrepresented by the population surveys, which may not adequately survey river reaches containing appropriate habitat for them. Population estimates per site for California roach ranged from 0 (95% CI, lower CI adjusted, 0-0) to 1,060 (95% CI, lower CI adjusted, 914-1,206) fish, and estimated fish per mile per site ranged from 0 to 18,656. Lengths of captured fish ranged from 1 to 7 inches, with 22% of California roach smaller than 2 inches and 91% smaller than 4 inches. Population estimates per site for Sacramento pikeminnow ranged from 1 (95% CI, lower CI adjusted, (1-1) to 1,441 (95%, lower CI adjusted, 378-2,952) fish, and estimated fish per mile per site ranged from 18 to 25,362. Lengths of captured fish ranged from 1 to 19 inches, with 82% of Sacramento pikeminnow smaller than 4 inches and 97% smaller than 6 inches. During the 2012-2016 drought, increases in the native cyprinid species were observed.

Lamprey are found in much of the Kings River. Population estimates per site ranged from 0 (95% CI, lower CI adjusted, 0-0) to 407 (95% CI, lower CI adjusted, 202-624) fish, and estimated fish per mile per site ranged from 0 to 7,163. Lengths of captured lamprey ranged from 2 to 7 inches, with 68% of lamprey in the 5 to 6 inch range.

Three-spine stickleback are a small but steady component of the Kings River, with increases seen during the 2012-2016 drought. Population estimates per site ranged from 0 (95% CI, lower CI adjusted, 0-0) to 559 (95% CI, lower CI adjusted, 129-1,750) fish, and estimated fish per mile per site ranged from 0 to 9,838. Lengths of captured fish ranged from 1 to 4 inches with 99% of three-spine stickleback smaller than 2 inches.

The “wild” rainbow trout population is small but persistent in the Kings River. During the 2012-2016 drought the “wild” rainbow trout population did experience a decline, with no “wild” trout captured in 2014, but showed signs of recovery to pre-drought levels in later years. Population estimates per site ranged from 0 (95% CI, lower CI adjusted, 0-0) to 24 (95% CI, lower CI adjusted, 7-200) fish while estimated fish per mile per site ranged from 0 to 422. Lengths of captured “wild” trout ranged from 4 to 22 inches with 22% of the fish less than 6 inches and 96% less than 12 inches. Length-weight regression analysis and calculations using Fulton's condition factor both indicate “wild” rainbow trout in the Kings River are in good condition.

Hatchery rainbow trout are detected annually and are distinguished from “wild” rainbow trout by either exhibiting abraded or missing fins from rearing in the hatchery or triploid blood cells are observed. Population estimates per site ranged from 0 (95% CI, lower CI adjusted, 0-0) to 41 (95% CI, lower CI adjusted, 26-79) fish while estimated fish per mile per site ranged from 0 to 722. Lengths of captured hatchery rainbow trout ranged from 4 to 20 inches with 23% of the fish less than 6 inches and 80% less than 12 inches. Length-weight regression analysis and calculations using Fulton's condition factor both indicate hatchery rainbow trout in the Kings River are in good condition.

Of the introduced non-native fish, bass of the *Micropterus* genera are most frequently detected in the Kings River. Bass population estimates per site ranged from 0 (95% CI, lower CI adjusted, 0-0) to 56 (95% CI, lower CI adjusted, 55-59) fish, and estimated fish per mile per site ranged from 0 to 986. Lengths of captured fish ranged from 2 to 11 inches, and 88% of bass were smaller than 5 inches. Also detected were bluegill, catfish, green sunfish, and western mosquitofish but in very low numbers. Increases in these species were observed during the 2012-2016 drought.

Fluctuations in fish populations are normal. While native fish continue to dominate the species assemblage throughout the Kings River, years when release temperatures were warmer, and instream flows lesser and of shorter duration, a moderate increase of non-native fish was observed. It is unlikely variations in species composition can be attributed to any single cause and more likely results from a combination of environmental and anthropogenic factors influencing the fishery populations. The KRCD and the KRFMP will continue monitoring and investigating environmental and population variables within the tailwater fishery.

INTRODUCTION

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 from 1983 to the present. The population monitoring began as part of a Federal Energy Regulatory Commission (FERC) requirement for compliance with Item 4 of the Memorandum of Agreement between CDFW and KRCD, for FERC Project No. 2741 and utilized by the Kings River Fisheries Management Program (KRFMP).

Numerous fish species inhabit the tailwater below Pine Flat Dam. Species detected during KRCD monitoring can be found in Table 1. While a great diversity of introduced non-native species have been detected in the Kings River since monitoring began in 1983, native species continue to be most abundant. The fish assemblage present is best described as that of the pikeminnow-hardhead-sucker assemblage described by Moyle (2002). For this assemblage, Sacramento suckers and Sacramento pikeminnow are usually the most abundant fish. Hardhead are restricted to cooler waters with deep rock-bottomed pools, while other native fish present may include tule perch, speckled dace, California roach, riffle sculpin, and rainbow trout (Moyle 2002). Introduced species such as small-mouth bass and green sunfish are present, but only become abundant when dams stabilize flow regimes as native fish are better adapted for survival during periods of extreme high flows and extended cool flows (Moyle 2002).

Table 1. ***Fish species which have been detected during monitoring activities of the Kings River below Pine Flat Dam since 1983.***

Species (Scientific Name)	Native	Introduced[a]
Bluegill (*Lepomis macrochirus*)	-	Y
Brook Trout (*Salvelinus fontinalis*)	-	Y
Brown Bullhead (*Ameiurus nebulosus*)	-	Y
Brown Trout (*Salmo trutta)*	-	Y
California Roach (*Lavinia symmetricus*)	Y	-
Common Carp (*Cyprinus carpio*)	-	Y
Golden Shiner (*Notemigonus crysoleucas*)	-	Y
Goldfish (*Carassius auratus*)	-	Y
Green Sunfish (*Lepomis cyanellus*)	-	Y
Hardhead[b] (*Mylopharodon conocephalus*)	Y	-
Kern Brook Lamprey[b] (*Lampetra hubbsi*)	Y	-
Largemouth Bass (*Micropterus salmoides*)	-	Y
Prickly Sculpin (*Cottus asper*)	Y	-
Rainbow Trout[c] (*Oncorhynchus mykiss*)	Y	Y
Riffle Sculpin[b] (*Cottus gulosus*)	Y	-
Sacramento Pikeminnow (*Ptychocheilus grandis*)	Y	-
Sacramento Sucker (*Catostomus occidentalis*)	Y	-
Smallmouth Bass (*Micropterus dolomieu*)	-	Y
Spotted Bass (*Micropterus punctulatus*)	-	Y
Three-spine Stickleback (*Gasterosteus aculeatus*)	Y	-
Western Mosquitofish (*Gambusia affinis*)	-	Y
White Catfish (*Ameiurus catus*)	-	Y

[a] introduced (anthropogenic introductions non-native to the watershed and hatchery trout)

[b] CDFW species of special concern

c distinction between native trout and those of hatchery descent not possible without genetic analysis

Since 1983 electro-fishing surveys have repeatedly sampled several locations over the years (Appendix A: Table A1). Survey methods, reach length, and the type of data collected in the thirty-six years since KRCD and CDFW biologists began conducting annual electro-fishing surveys is summarized in Appendix A: Table A2. A multiple-pass mark-and-recapture electro-fishing survey was employed from 1983 through 1989. In 1990, the annual electro-fishing survey was modified to a single pass count of captured fish using only a single block seine net at the upstream end of each 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 thought to be a result of extreme drought conditions (KRCD 1993). The single pass reaches were expanded in length 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, uncertain population abundance estimates that do not support rigorous statistical analysis.

In the fall of 2007 the Kings River Fisheries Management Program's Technical Steering Committee (TSC), which consists of representatives of the CDFW, the KRCD, and the KRWA revised the electro-fishing survey protocol to a multi-pass depletion technique with upstream and downstream block seines, which resulted in improved statistical rigor and the ability to estimate 95% confidence intervals on abundance estimates. Multi-pass surveys allow for more rigorous sampling and provide a more complete assessment of the species composition and abundance found in the sample site. This data can then be used to determine trends in the populations and condition of sampled fish species. Surveys are conducted at the same sampling sites each year for use in establishing an abundance index, and for determining trends in abundance of trout and other fish species.

Data entered from the 2007-2019 surveys was compared against field notes to check for input errors or missing data in species collected, recorded weights, lengths, trout origin, or trout age. When discrepancies were found, corrections were made to the input files and the data reanalyzed. Results of the 2007 through 2019 surveys are presented here to show trends in the fishery over the multi-pass depletion sampling period.

While the duration of the sampling period has included both wet and dry years, instream flow releases from Pine Flat Dam are dictated by the Framework Agreement set forth by the Kings River Fisheries Management Program, irrigation demands of downstream water users, and by mandated Army Corps of Engineer releases which maintain flood control space within the reservoir. Under the Framework Agreement, Exhibit "C" provides the target minimum flows below Pine Flat Dam when Kings River runoff is 1,555,000-acre feet or less (Table 2). Also under the Framework Agreement, Exhibit "D" allows for enhanced minimum flow to Fresno Weir when the runoff of a preceding water year exceeds 1,555,000-acre feet. When total runoff is between 1,555,000-acre feet and 2,100,000-acre feet the minimum flow is 130 cubic feet per second (cfs), and when runoff exceeds 2,100,000-acre feet the minimum flow is 250 cfs (KRFMP 1999). These enhanced flows begin on the date the minimum flow at

Fresno Weir would otherwise fall below the enhanced minimum flow target of either 130 or 250 cfs and lasts until March 31. While instream high flow events are delayed until irrigation or flood releases are ordered, minimum flows established under the Framework Agreement are set to ensure benefits to aquatic resources are available year-round between Pine Flat Dam and Highway 180.

Table 2. ***Exhibit "C" target flows from the Framework Agreement.***

	1 Oct - 15 Nov	16 Nov - 31 Mar	1 Apr - 30 Sep
Total Flow at Piedra	100	100	100
Minimum Flow in Dennis Cut	5	5	5
Minimum Flow to Fresno Weir	95	95	95
Water Divertable in China Slough	10	5	15
Required Flow over Fresno Weir	40	45	35

Water deliveries and irrigation flows typically occur from May through August and flood releases may be made at any time, but typically occur in the winter and spring (Figure 1). Temperature of released water is typically the coldest during the first half of the year, with warming increasing towards the middle to end of the irrigation season. Hot daytime temperatures combined with long days and reservoir drawdown contribute to an increase in warm water releases and increased instream temperatures from July through October (Figure 2, Figure 3) which can be partially mitigated through blending of different reservoir outlets, particularly when releases from the low-level sluices are allowed by the Army Corps of Engineers.

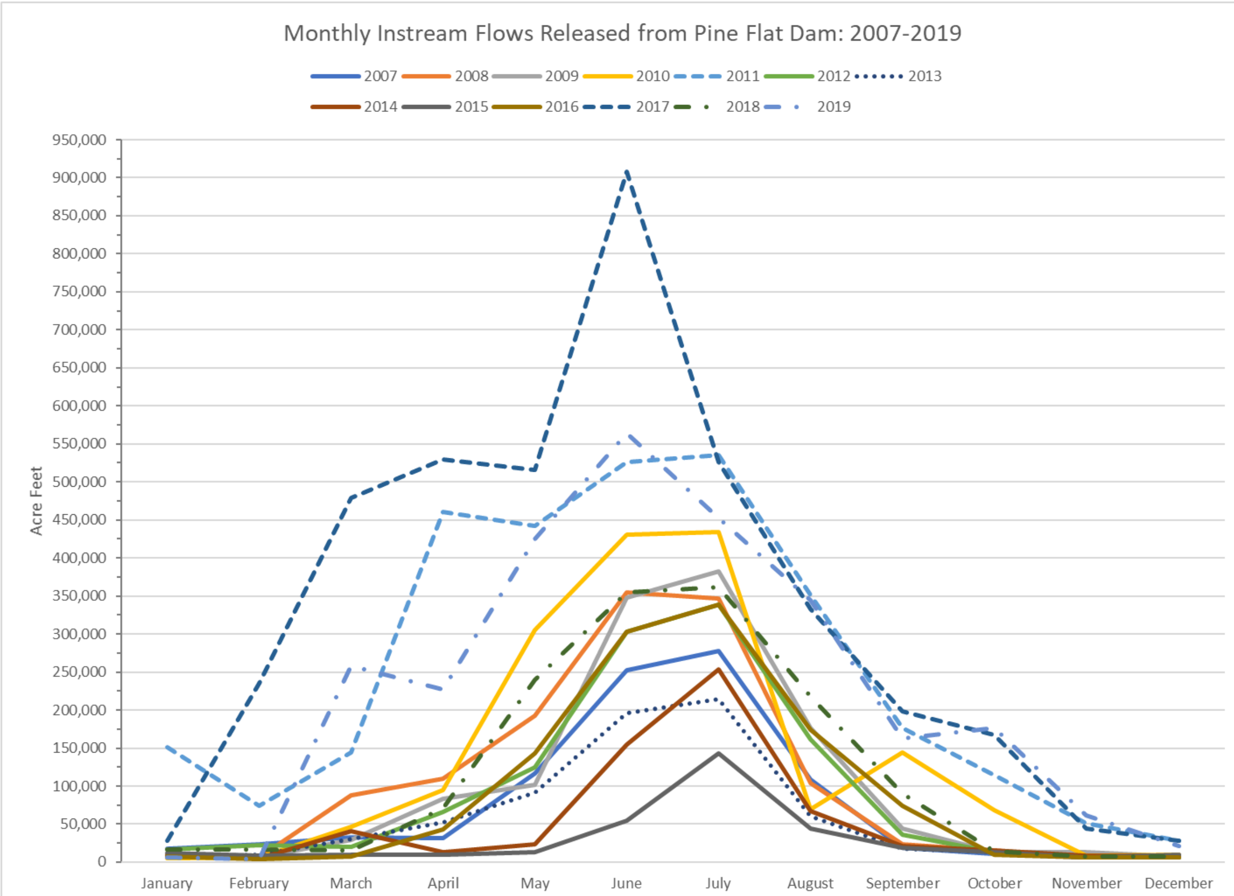

Figure 1. ***Monthly instream flows released from Pine Flat Dam, 2007-2019.***

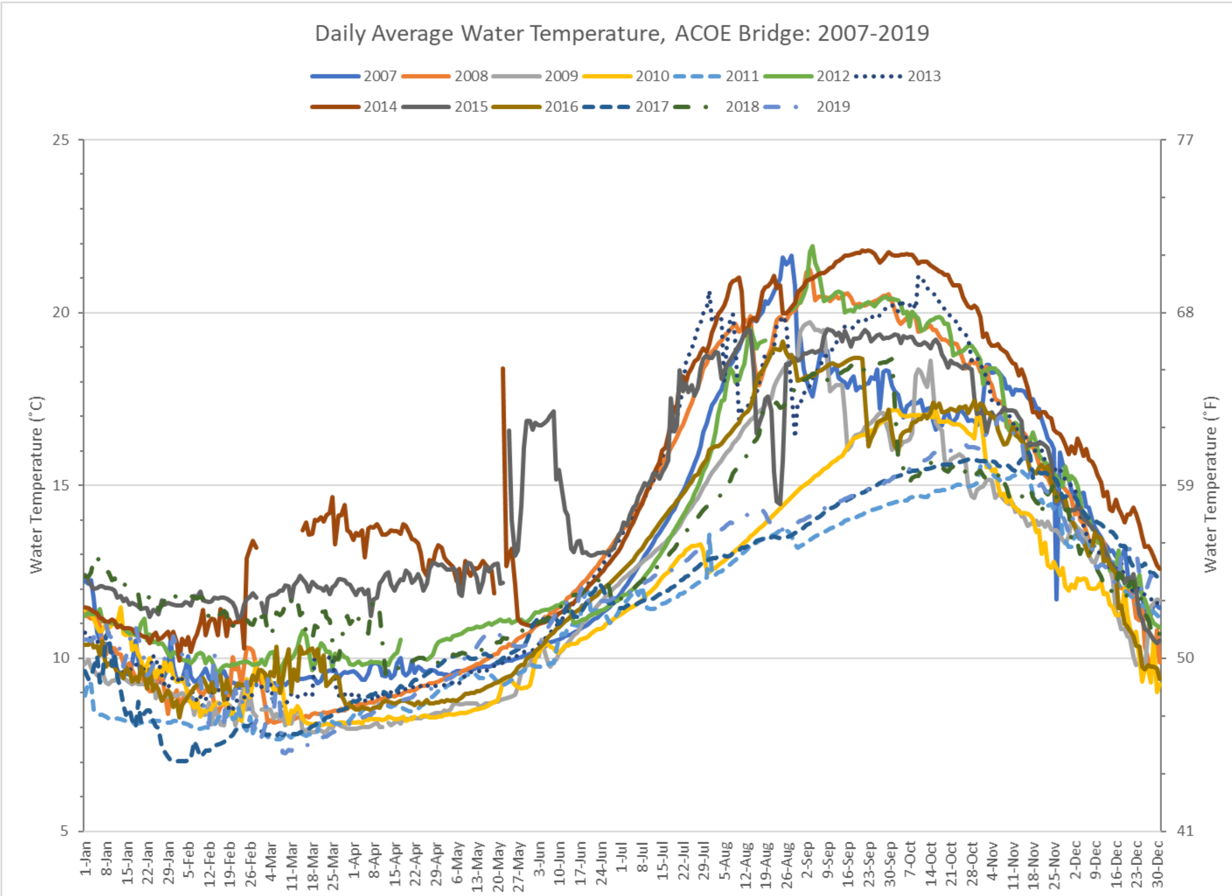

Figure 2. ***Daily average water temperature at the Army Corps of Engineer Bridge, 2007-2019.***

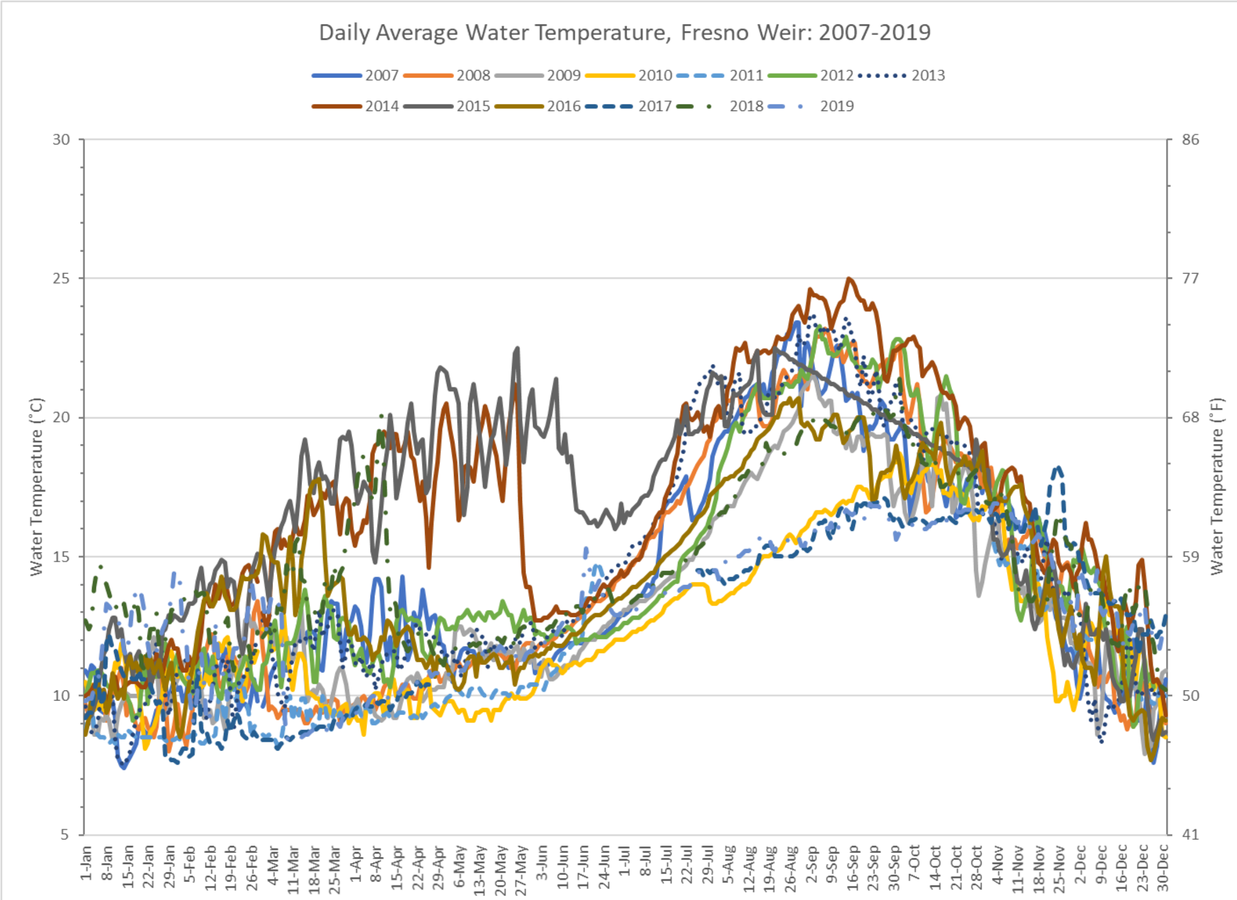

Figure 3. ***Daily average water temperature at the Fresno Weir, 2007-2019.***

METHODS

Survey Area

Electro-fishing is performed at two sampling sites within each of the three uppermost management reaches of the lower Kings River (Figure 4). Reach One, which consists of the section of river between Pine Flat Dam and Alta (Cobbles) Weir, is managed as a put-and-take trout fishery, permitting take of up to five trout daily, excluding the area above the ACOE Bridge which has been closed to fishing by order of Homeland Security since September 2001. Additionally, within Reach One, the Thorburn Channel and a 200-foot radius from the channel exit are also closed to fishing by CDFW regulations. There are no diversions by KRWA member units in Reach One which also receives uncontrolled inflows from the tributaries of Mill and Hughes Creeks. Both Reach Two and the upper portion of Reach Three are managed as a catch-and-release trout fishery, with special regulations permitting zero take of trout and prohibitions on the use of bait and barbed hooks between Alta (Cobbles) Weir and the Highway 180 crossing. Reach Two is located between Alta (Cobbles) Weir and Fresno Weir while Reach Three consists of the portion of river from Fresno Weir to the Reedley Narrows gauging station. This reach is considered an opportunistic trout fishery as water temperatures downstream of Fresno Weir may not remain suitable for trout in most years, and limited trout stocking occurs. Several water diversions occur within Reach Two. The first diversion of Kings River water occurs at the Alta (Cobbles) Weir where the '76 Channel, operated by Alta Irrigation District, diverts water off the river's left which is conveyed to the Alta Canal. Dennis Cut Weir, located downstream of Avocado Lake Park diverts water from the left bank of the Dennis Cut channel to the Alta Canal. Gould Weir, two miles downstream of Alta (Cobbles) Weir, operated by Fresno Irrigation District, diverts water from the right bank into Gould and Enterprise Canals. At Fresno Weir, water is diverted on the right bank by Fresno Irrigation District into the Fresno Canal, and the Consolidated Irrigation District's Consolidated Canal. The Consolidated Canal is the largest single diversion on the King's River. Additionally, within Reach Two, immediately upstream of Fresno Weir, the Friant-Kern Canal crosses under the Kings River. On occasion, water deliveries via the Friant-Kern Canal are provided through the Kings River above Fresno Weir.

Within Reach One electro-fishing occurs at the sites Winton and Alta. Winton is located downstream of Winton County Park and is adjacent to the Thorburn Spawning Channel. This site is a partial subset of the historic sampling site Winton Park Boulder. This site is characterized by a wide channel, large cobble, anthropogenically placed boulders, minimal streamside vegetation, and no tree cover. Site Alta is a partial subset of the historic sampling site Alta Weir/Site A and is upstream of Alta Weir in the left-hand channel of the river. The bottom of the site is narrow, characterized by a deep run (three to four feet) and shallow riffle. Above the riffle the channel widens into a glide of moderate depth (two to three feet deep). The bottom consists primarily of medium sized cobble. Tree canopy provides shading throughout the glide.

Within Reach Two electro-fishing occurs at the sites Avo Boulder and Avo Side. Avo Boulder is a partial subset of the historic sampling site Avocado Lake Boulder. This site is in the middle channel behind Avocado Lake Park. This site is characterized by large cobble, many anthropogenically placed boulders, and some vegetative cover is provided by trees. The site Avo Side is a partial subset of the historic sampling site Avocado Lake Side Channel and is located on private property downstream of Avocado Lake Park. This site is characterized by large cobble, many anthropogenically placed boulders, and extensive canopy cover is provided by adjacent trees.

Within Reach Three electro-fishing occurs at the sites Greenbelt and Wildwood. Greenbelt is a partial subset of the historic sampling site County Park Land Boulder. This site is located near the bottom of Greenbelt County Park and is characterized by a wide channel with small to medium sized cobble and a few anthropogenically placed boulders. Some canopy cover is provided by mature trees along the left bank, minimal vegetative canopy cover is provided along the right bank. Most of the survey site is characterized by moderately deep water (two to three feet deep) throughout, a small riffle on the right bank near the top of the survey site, and a small deep pool (four to five feet deep) located along the left bank. The site Wildwood is a partial subset of the historic sampling site Wildwood. This site is in the Wildwood subdivision. This site is characterized by small to medium sized cobble, shallow glides, fast riffles, and extensive tree canopy.

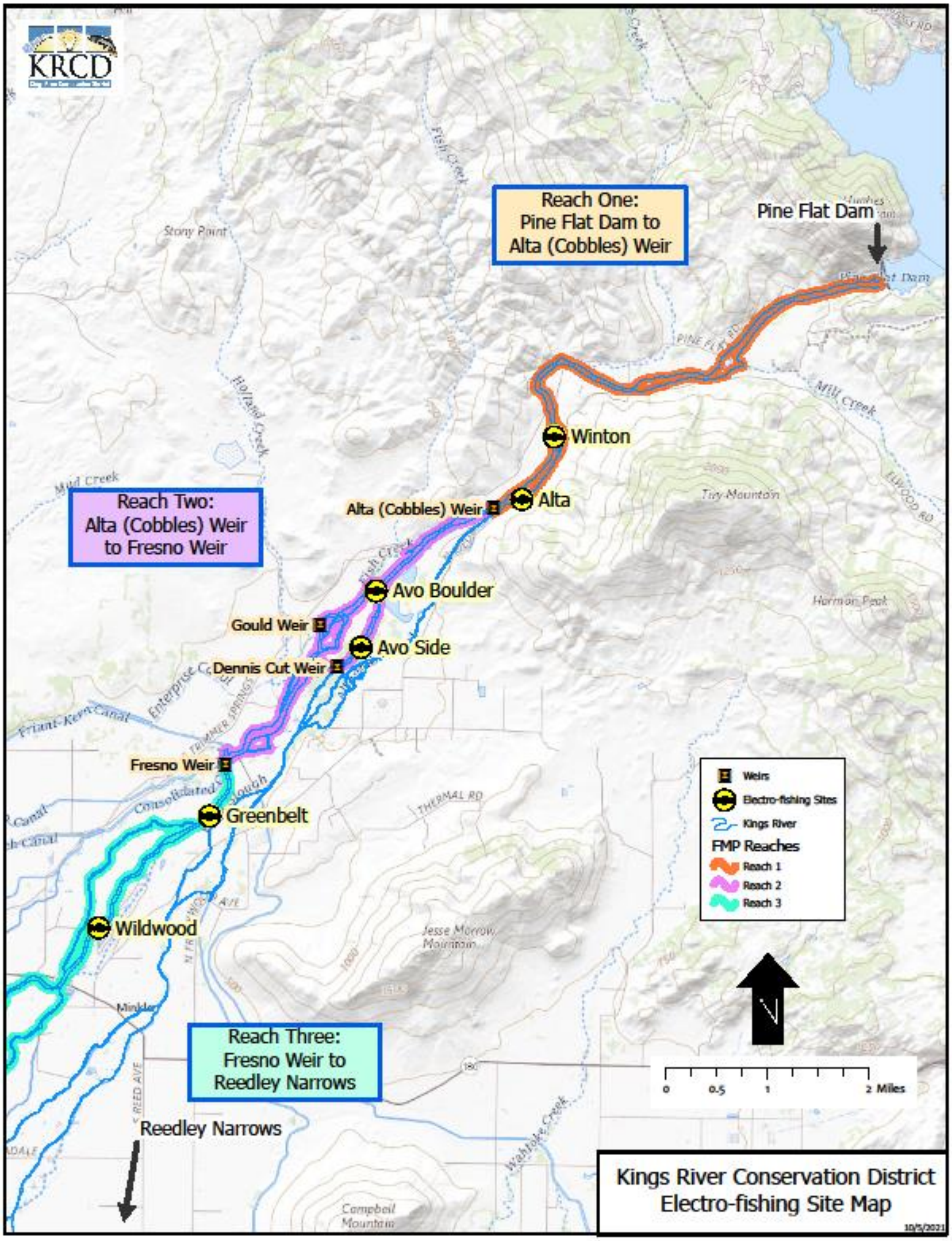

Figure 4. ***Electro-fishing sites in the Kings River, 2007-2019.***

Efforts are made to survey these same six sites each year, with some exceptions. In 2007 three additional sites were sampled, and in 2010 two additional sites were sampled (Appendix A: Table A1). Results of surveys for the additional sites have been excluded from this analysis to provide the most standardized comparison of data between sites and years. Unfortunately, of the six sites routinely sampled, only two have been sampled in all years (Appendix A: Table A1). Unsafe wading conditions resulted in sampling fewer than the six sites in both 2017 and 2019. In 2017 only Greenbelt and Avo Side were sampled due to high water levels and in 2019 Alta could not be sampled due to inclement weather. For 2017 and 2019 data can only be effectively compared among sites sampled in all years as overall averages for surveys in those years will be skewed due to the limited number of sites sampled.

Survey Methods

Sampling from 2007 through 2019 occurred in November or December of each year using standard multiple-pass depletion electro-fishing techniques (Reynolds 1996). Survey sites were 300 feet in length and both the upstream and downstream ends of each survey reach were netted with ¼-inch mesh block seines to avoid fish immigration or emigration from the sampling reach. Four to nine electro-fisher backpack units were utilized in each survey reach. Electro-fisher backpack models operated between 2007 and 2019 consisted of the Smith-Root Model 12, Smith-Root LR-24, or Smith-Root LR-20B.

From 2007 – 2011 electro-shocker settings were standardized at 350 volts, 10% Duty Cycle, and a 50Hz frequency. To safely maximize catch-per-unit effort (CPUE), tests were conducted using the LR-24 backpack electro-fisher prior to the 2012 population survey. These tests specifically targeted fish response in the presence of an electrical field. It was quickly determined that the previous settings (350 volts, 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 to illicit the desired response.

By adjusting the electro-fisher settings, the voltage required to overcome the mismatch between water conductivity and fish conductivity could be achieved. Data collected from the LR-24 backpack electro-shockers internal voltmeter was used to generate a peak voltage goal chart (Table 3) based on water conductivity (μS/m) observed in the lower Kings River downstream of Pine Flat Dam. This chart has been used to guide shocker voltage settings since 2012. Additionally, a Duty Cycle of 20% and a Frequency of 30Hz resulted in a high capture rate, quick recovery time, and minimal mortality when compared to settings prior to 2012 and have been adopted for all surveys since.

Table 3. ***Voltage goals for Smith-Root electro-shockers used for the Kings River population surveys, 2012-2019.***

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

Electro-fishing was conducted using four to nine, three-person crews and one or two data processing teams. Each crew consisted of a backpack electro-fisher operator, one or two netters, and a person with a five-gallon bucket to hold collected fish. Data processing teams consisted of one data recorder and one or two biologists. Volunteers and staff from KRCD, CDFW, KRWA, California Department of Water Resources, Reedley College, the Kings River Conservancy, local fly-fishing clubs, and other members of the public participated in the surveys. After data collection was complete, captured fish were released outside of the netted survey reach. A minimum 30-minute hiatus was taken between passes.

During electro-fishing, releases from the dam are preferentially targeted between 100 and 150 cfs (Appendix A: Table A3), as this allows for safe wading and effective capture of stunned fish. To allow for sampling to occur when the water demand from downstream users exceeds safe flows for wading, releases from the dam are pulsed during electro-fishing following the ramping schedule outlined in the Framework Agreement (KRFMP 1999). Releases are ramped down at a predetermined time so that target flows at the sampling site are present during electro-fishing. Releases are then ramped up again in the afternoon to meet downstream water delivery needs. This ramping cycle prevents negative impacts on the fishery and allows for surveyors to safely enter the water and complete the sampling effort while still meeting the KRWA's obligation to its water users.

Data Collection

In the field, each fish was identified by a biologist to the lowest practical taxon, weighed to the nearest tenth of a gram, and total length measured to the nearest 1 millimeter, except for rainbow trout which were measured to fork length and also photographed. From 2008 through 2019 scale samples were taken from most "wild" and some hatchery rainbow trout between the dorsal fin and lateral line for aging. However, residency in a tailwater below a dam can make age determination difficult as relative temperature uniformity makes it difficult to distinguish the presence of annuli. As a result of uncertainty and inconsistencies of the recorded trout ages, age class data has not been included in this report. Rainbow trout were classified in the field as either hatchery trout or "wild" trout based on characteristics observed while in hand. In five years (2009, 2010, 2012, 2016, 2017) blood samples were collected from the caudal vein via syringe to determine if a captured trout was diploid or triploid. For rainbow trout triploidy is an unnatural condition induced in the fish hatchery during fertilization which renders the resultant fish sterile. Through laboratory analysis of the collected blood sample, it was possible to determine if a rainbow trout was diploid, the natural condition, or triploid, thus providing an additional means to distinguish between hatchery and "wild" trout during those years triploid hatchery rainbow trout were introduced into the river from either the KRFMP trout incubator or the CDFW fish hatchery.

CDFW (2010) defines a wild trout as "A trout that was born in the wild and lives its life cycle in the wild, regardless of the origin of its parents." Since 1983 KRCD has used visual inspection of fin condition as the primary means to distinguish between "wild" and hatchery origin rainbow trout. Rainbow trout with fins in excellent condition were classified as "wild" rainbow trout while rainbow trout exhibiting missing or abraded fins were categorized as hatchery rainbow trout. In the years a blood sample was collected, any diploid trout were classified as "wild" rainbow trout while triploid trout were classified as hatchery rainbow trout. Because of morphological similarity, trout of alternate origins may be misclassified as "wild". There may be little morphological difference in rainbow trout assumed to have originated via natural in-river reproduction, the KRFMP incubator facility, or hatchery trout who have carried over from a past season.

Biological data was manually recorded on data sheets printed on waterproof paper. Raw capture data was later entered into an Excel spreadsheet. MicroFish 3.0 (Van Deventer 2006) was then used to determine total catch, biomass, and maximum likelihood population estimates.

Catch-Per-Unit Effort

Catch-per-unit 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 per site, 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 as the collective time (seconds) that each shocker in the group was energized during the three survey passes at each site. Each backpack electro-fisher 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 collected.

Population Estimate

Maximum population estimates and 95% adjusted confidence intervals for each species are automatically generated for each sampled 300-foot site in MicroFish 3.0. These numbers are influenced by the removal pattern (number of fish of each species removed in each electro-fishing depletion pass) and sample size. Non-descending removal patterns in each pass and a small sample size may lead to population estimates with broader confidence intervals. In some instances, the lower value of the confidence interval may be negative. Because the species was present in the sampled reach the population value cannot be negative. To correct for this negative value, MicroFish 3.0 is asked to adjust the lower confidence interval.

Fish-Per-Hectare

Fish-per-hectare ($fish{\cdot}ha^{-1}$) is a population density estimate which takes the maximum population estimate generated by MicroFish 3.0 of species 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.

Fish per Mile

Fish per mile is calculated using the maximum population estimate generated by MicroFish 3.0 for each species collected from the survey sites located between Pine Flat Dam and Highway 180. Each survey site equals 300 feet in length. This estimate can be used as an index to monitor changes in fish density.

Condition Factor

Fulton's condition factor (K-factor) is an index of an individual salmonid's body fitness and condition. The score is based upon a mathematical formula (Fulton 1904) which utilizes length (mm) and weight (g) parameters to determine the fitness of individuals within a population.

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

Fulton's K-factor allows for a quantitative assessment of the condition of an individual fish within a population, individual fish from different populations, and two or more populations from different localities (Barnham and Baxter 1998) with the assumption that heavier fish of a given length are in better condition (Bolger and Connolly 1989, Shah et al. 2011). A fish is said to be in better condition when the value of a Fulton's 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 (Shah et al. 2011).

Fulton's condition factor assumes isometric growth and may differ depending on the length of the fish. To further support K-factor results, length-weight relationship analysis was also conducted in Microsoft Excel for trout. For this analysis length-weight data was transformed using log base 10 (Log10). The data was plotted and a linear trendline applied. Slope of the trendline was calculated to determine fish condition. Because length and weight are interrelated, a logarithmic value between 2.5 and 3.5, but usually close to 3.0 is expected for fish populations in good condition (Sharma and Baht 2015). A value of 3.0 indicates fish are growing isometrically as opposed to allometrically. For values less than 3.0 weight is increasing at a slower rate relative to length, and for values greater than 3.0 weight is increasing at a faster rate relative to length (Sharma and Baht 2015). The R-squared (R^2) value of the trendline was calculated to determine goodness of fit to the data.

Reporting of Results

Past annual electro-fishing reports data have presented results in a manner which suggests the sampled sites are representative of the Kings River in the 12.5 miles below Pine Flat Dam and that the overall sampling effort of those sites was the same in all years. The six sites sampled below Pine Flat Dam may not be representative of the 12.5 miles of river below Pine Flat Dam, and sampling effort between years varied. While the same sites were visited whenever possible, unsafe conditions precluded sampling in all six sites in two of the years (2017, 2019). Because not all sites were sampled in those years the overall data collected in those years cannot be accurately compared with other years while data for sampled sites can be. For these reasons, results pertaining to CPUE, population estimates, estimated fish-per-hectare, and estimated fish per mile are presented based on the individual sample sites rather than extrapolated to apply to the Kings River below Pine Flat Dam. However, results showing the overall fish assemblage, length-frequency of captured fish, and overall condition factor (K-factor) of captured trout has been combined for the thirteen-year period covered in this report.

RESULTS AND DISCUSSION

A total of 48,122 fishes collected from the Fall Population Electro-fishing Surveys of 2007-2019 are included in this analysis. Species collected are presented in Table 4 and Appendix B. Native fish have dominated the surveys in all years in both abundance and biomass, with the species assemblage between Highway 180 and Pine Flat Dam consisting of on average 99.0% native fish from 2007-2019. Annual variation in the population was most notable amongst California roach (4.5% to 35.3%), Sacramento pikeminnow (2.9% to 31.0%), Sacramento sucker (13.0% to 47.5%), sculpin (4.9% to 46.2%), and three-spine stickleback (1.4% to 10.0%). Introduced fish were captured in all years, but in low numbers. Introduced species regularly collected were bass (0% to 1.4%), catfish (0% to 0.5%), hatchery rainbow trout (>0.1% to 1.9%), and western mosquitofish (0% to 1.3%). While populations of different species fluctuated over the years, the assemblage continued to be dominated by native Sacramento suckers, sculpins, and the various cyprinid species. The presence and quantity of these fish suggest the assemblage immediately below Pine Flat Reservoir most accurately resembles that of the pikeminnow-hardhead-sucker assemblage described by Moyle (2002). While deep-bodied fishes were present, they typically comprised less than one percent of the species assemblage in most years (Table 4). Trout were present but were typically no more than one percent of the species assemblage (Table 4), as expected for a low elevation, low gradient, fish assemblage.

Table 4. ***Species Composition by percent abundance for fish collected during the Fall Population Electro-fishing Surveys, 2007-2019.***

Species Composition by Percent (%): 2007-2019													
Species	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
Bass sp.[a]	0.0	0.0	0.1	0.0	0.0	0.0[f]	0.1	0.7	1.4	0.3	0.2	0.0[f]	0.0
Bluegill[a]	0.0	0.0	0.0[f]	0.0	0.0	0.0	0.0	0.0	0.0	0.0[f]	0.0	0.0	0.0
Brook Trout[a]	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
California Roach	4.5	23.2	19.2	21.0	16.3	9.9	19.0	25.7	35.3	25.9	19.8	8.6	7.3
Catfish sp.[a]	0.0	0.1	0.1	0.0	0.0	0.0[f]	0.0[f]	0.5	0.0[f]	0.0	0.0	0.0[f]	0.3
Green Sunfish[a]	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0[f]	0.4	0.0	0.0
Hardhead[b]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0[f]	0.0
Lamprey sp.[c]	6.5	5.0	5.3	3.7	8.5	4.8	2.5	8.9	4.4	5.0	9.4	4.8	10.5
Rainbow Trout - "Wild"[d]	0.4	1.0	0.7	0.4	0.5	0.7	0.2	0.0	0.0[f]	0.1	0.2	0.3	0.8
Rainbow Trout - Hatchery[a]	0.9	0.0[f]	0.1	0.2	0.5	0.1	0.1	0.0[f]	0.0[f]	0.2	0.4	0.3	1.9
Sacramento Pikeminnow	17.7	19.4	14.2	7.2	4.7	10.0	31.0	23.1	18.7	6.6	2.9	4.3	3.5
Sacramento Sucker	37.6	26.0	18.5	17.9	19.7	39.6	19.2	13.0	31.0	47.5	36.0	40.4	33.1
Sculpin sp.[e]	30.9	21.2	37.8	44.4	46.2	32.5	24.4	17.6	4.9	5.1	22.6	39.5	40.3
Three-spine Stickleback	1.4	4.0	3.9	4.8	3.5	2.1	3.5	10.0	2.8	8.7	8.2	1.8	2.3
Western Mosquitofish[a]	0.0	0.1	0.0	0.0	0.0	0.2	0.0[f]	0.5	1.3	0.5	0.0	0.3	0.0
% Introduced	0.9	0.2	0.3	0.5	0.6	0.3	0.2	1.7	2.7	1.0	1.0	0.6	2.2
% Native	99.0	99.8	99.6	99.4	99.4	99.6	99.8	98.3	97.1	98.9	99.1	99.7	97.8

[a] introduced (anthropogenic introductions non-native to the watershed and hatchery trout)

[b] CDFW species of special concern

[c] Kern Brook lamprey only species confirmed present, others possible; Kern brook is CDFW species of special concern

[d] "wild" trout can not be phenotypically distinguished from incubator-hatched trout, thus may include trout of incubator origin

[e] two species present, riffle sculpin and prickly sculpin; riffle sculpin is CDFW species of special concern

[f] captured but represents less than 0.1% of total fish captured

These species represent nine families: 1) Catostomidae (suckers), 2) Centrarchidae (sunfishes, crappies, and "black" basses), 3) Cottidae (sculpins), 4) Cyprinidae (minnows), 5) Gasterosteidae (sticklebacks), 6) Ictaluridae (catfishes and bullheads), 7) Petromyzontidae (lampreys), 8) Poecillidae (livebearers), and 9) Salmonidae (trout and salmon). The results are summarized below, with figures and tables provided for those species whose combined capture by family made up ten percent of the catch from 2007-2019, excepting species within those families where fewer than 150 individuals were captured. When figures or tables are not provided, they are summarized in the text.

Catostomidae – Sucker Family

A total of 14,747 catostomids, represented by the Sacramento sucker were captured between 2007 and 2019 (Appendix B). Catch-per-unit effort is shown in Figure 5 and provided in Appendix C. Catch rates varied both between sites, and between years, with the Greenbelt site having a similar CPUE in 2010 and 2011 suggesting no change in site effort or abundance between sampling years. All other sites showed considerable variation between years, reflecting possibly a change in abundance, although a change in effort could have affected capture success.

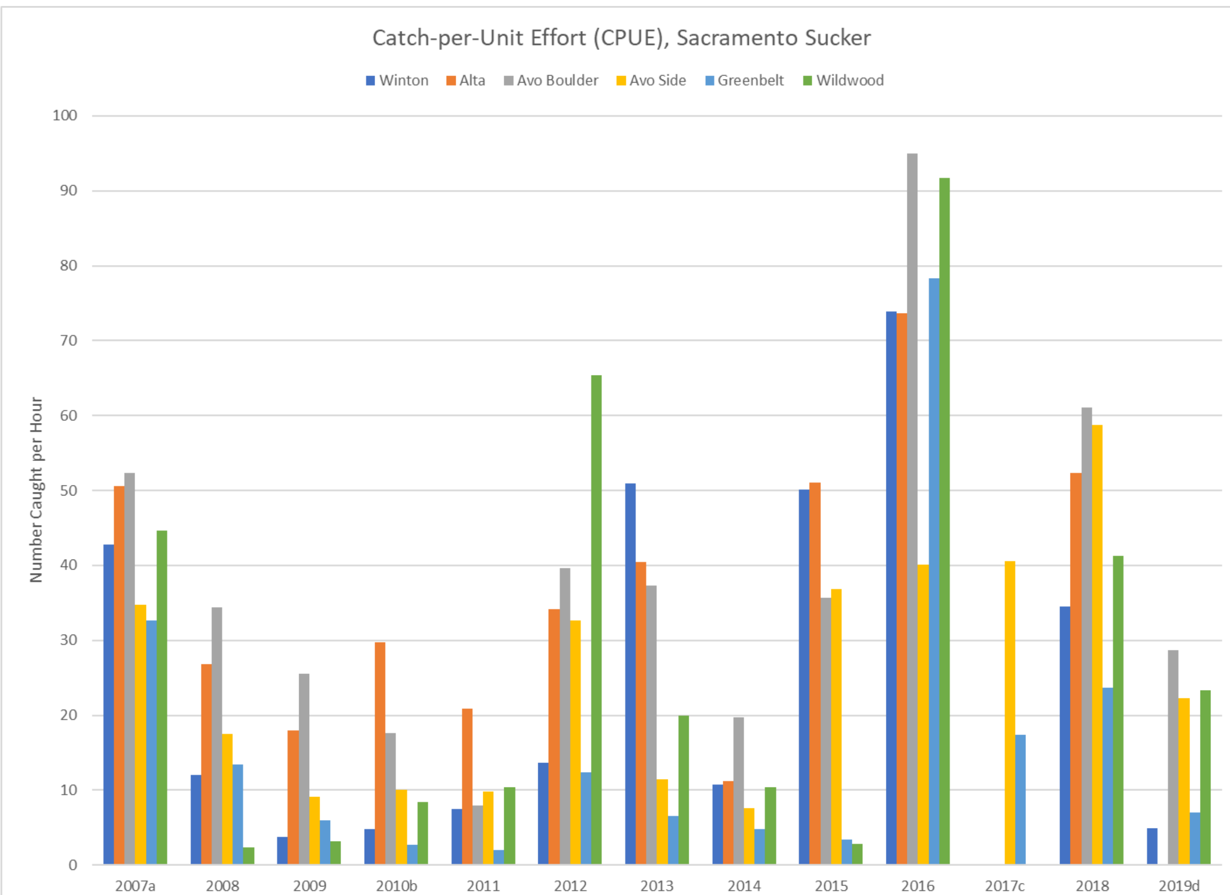

Figure 5. ***Catch-per-unit effort and number of Sacramento suckers captured per hour during the Fall Population Electro-fishing Survey, 2007-2019. Note that in 2007a nine sites were sampled, and in 2010b eight sites were sampled; data shown only represents that from the six core sites sampled annually. Due to unsafe survey conditions, two sites were sampled in 2017c, and five sites in 2019d.***

Population estimates for Sacramento sucker are summarized in Table 5 by site and year. The estimated population density per site varied among years (Figure 6). The smallest estimated population density occurred in the Greenbelt site in both 2010 and 2011 with 52 fish*ha^{-1}. The site with the greatest estimated population density was Avo Boulder with 6,082 fish*ha^{-1} in 2016. All sites experienced an increase in estimated population density from 2015 to 2016. For Alta the increase was 4%, Avo Boulder increased by 182%, Avo Side by 9%, Greenbelt by 2,289%, Wildwood by 3,208%, and Winton by 57%. It is presumed riverine conditions were optimal for reproduction in 2016. The average length of the 2,815 Sacramento suckers captured in 2016 was 3 inches (88 mm), suggesting many juveniles were present. Sucker populations are typically variable. High reproductive output typically occurs after some event triggers a massive die-off, with the survivors flooding the environment with offspring in succeeding years, or the strong presence of one or two age classes may inhibit reproduction through competition for food and space (Moyle 2002). Additionally, spawning which occurs over gravel riffles, typically occurs from February through early June, and is triggered when flows increase, and temperatures range from 42˚F (5.6˚C) to 51˚F (10.6˚C) (Moyle 2002). If spawning is triggered by flow increases, in most years covered by this report, spawning of suckers in the Kings River may have been delayed or resulted in a limited spawning period as flows were frequently low until mid-April (Figure 1).

Table 5. ***Population estimates for Sacramento sucker, 2007-2019, with 95% CI, lower CI adjusted in parenthesis, as calculated by MicroFish 3.0.***

Population Estimate (95% CI, Lower CI Adjusted), Sacramento Sucker						
Year	**Winton**	**Alta**	**Avo Boulder**	**Avo Side**	**Greenbelt**	**Wildwood**
2007[a]	838 (326-1,373)	535 (494-576)	573 (466-680)	372 (372-372)	344 (309-379)	368 (336-400)
2008	107 (82-138)	231 (162-300)	261 (236-286)	112 (99-127)	119 (103-136)	25 (16-55)
2009	35 (29-48)	141 (122-160)	257 (238-276)	64 (54-79)	64 (53-81)	28 (19-54)
2010[b]	42 (41-46)	207 (192-222)	162 (122-202)	45 (42-51)	14 (14-15)	133 (62-278)
2011	93 (93-93)	112 (98-128)	88 (68-115)	54 (44-71)	14 (13-19)	156 (77-293)
2012	128 (107-150)	466 (428-504)	415 (369-461)	319 (267-371)	109 (98-122)	765 (765-765)
2013	450 (396-504)	268 (258-278)	296 (269-323)	88 (73-107)	69 (51-98)	202 (168-236)
2014	121 (114-130)	100 (89-113)	174 (151-197)	71 (67-78)	34 (34-36)	93 (80-109)
2015	538 (477-599)	536 (438-634)	366 (317-415)	268 (215-321)	24 (24-26)	25 (23-31)
2016	844 (685-1,003)	556 (462-650)	1034 (836-1,232)	291 (225-357)	574 (532-616)	827 (639-961)
2017[c]	-	-	-	361 (337-385)	197 (171-223)	-
2018	595 (500-690)	510 (444-576)	517 (445-589)	552 (446-658)	215 (182-248)	506 (420-592)
2019[d]	66 (66-66)	-	210 (181-239)	201 (161-241)	102 (53-201)	401 (158-762)

[a] = nine sites sampled, but data shown represents only that from the six core sites sampled annually

[b] = eight sites sampled, but data shown represents only that from the six core sites sampled annually

[c] = only two sites sampled due to unsafe flows for surveying at other sites

[d] = only five sites sampled due to adverse weather at Alta creating unsafe survey conditions

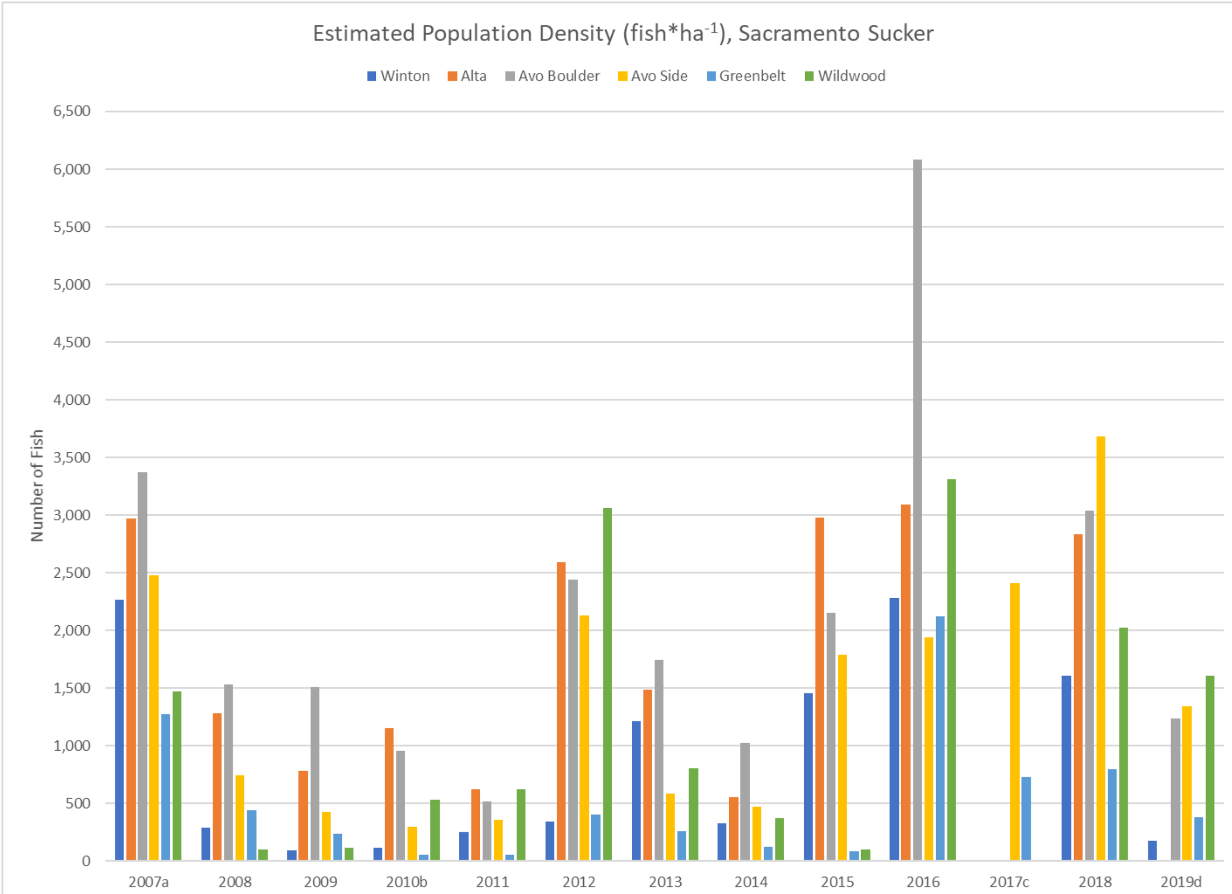

Figure 6. ***Estimated population density of Sacramento suckers per site during the Fall Population Electro-fishing Survey, 2007-2019. Note that in 2007a nine sites were sampled, and in 2010b eight sites were sampled; data shown only represents that from the six core sites sampled annually. Due to unsafe survey conditions, two sites were sampled in 2017c, and five sites in 2019d.***

Fish per mile estimates were variable from year to year. The lowest estimated number of Sacramento suckers occurred in both 2010 and 2011 at Greenbelt with 246 fish per mile, and the highest estimated number at 18,198 fish per mile in 2016 at Avo Boulder (Figure 7). Because suckers can exploit flow regimes ranging from cold and fast to slow and warm and are tolerant of temperatures up to 86˚F (30˚C) (Moyle 2002) fish per mile within the Kings River is high.

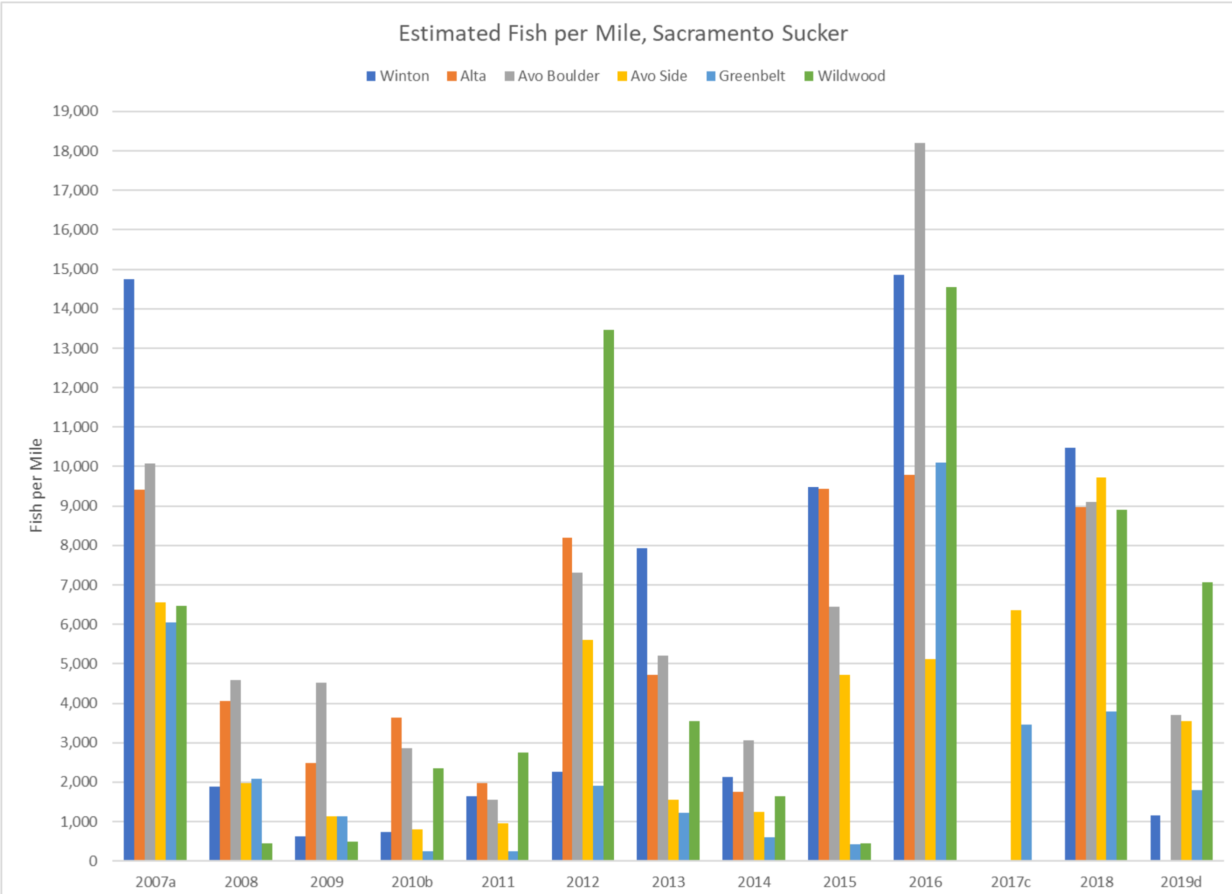

Figure 7. ***Estimated number of fish per mile for Sacramento suckers per site during the Fall Population Electro-fishing Survey, 2007-2019. Note that in 2007a nine sites were sampled, and in 2010b eight sites were sampled; data shown only represents that from the six core sites sampled annually. Due to unsafe survey conditions, two sites were sampled in 2017c, and five sites in 2019d.***

Biomass of captured Sacramento suckers was highly variable. The lowest biomass captured was 0.5 pounds (234 g) in Winton in 2019, and the heaviest biomass captured was 214 pounds (96,916 g) in Avo Boulder in 2007 (Figure 8). Fish captured in Avo Boulder, where large adult suckers are routinely captured, consistently provided the greatest contribution to the annual biomass. Biomass has seen a decline, particularly at Avo Boulder and Greenbelt since the 2007 through 2009 period, suggesting a change in the age structure of the population. In each of 2007 through 2009, more than 100 (average 112) Sacramento suckers greater than 15 inches (381 mm) were caught over the six-day annual sampling period. From 2010 through 2019, the number of Sacramento suckers greater than 15 inches (381 mm) ranged from 0 to 58 (average 23) over the annual sampling period. This suggests a reduction of older age classes.

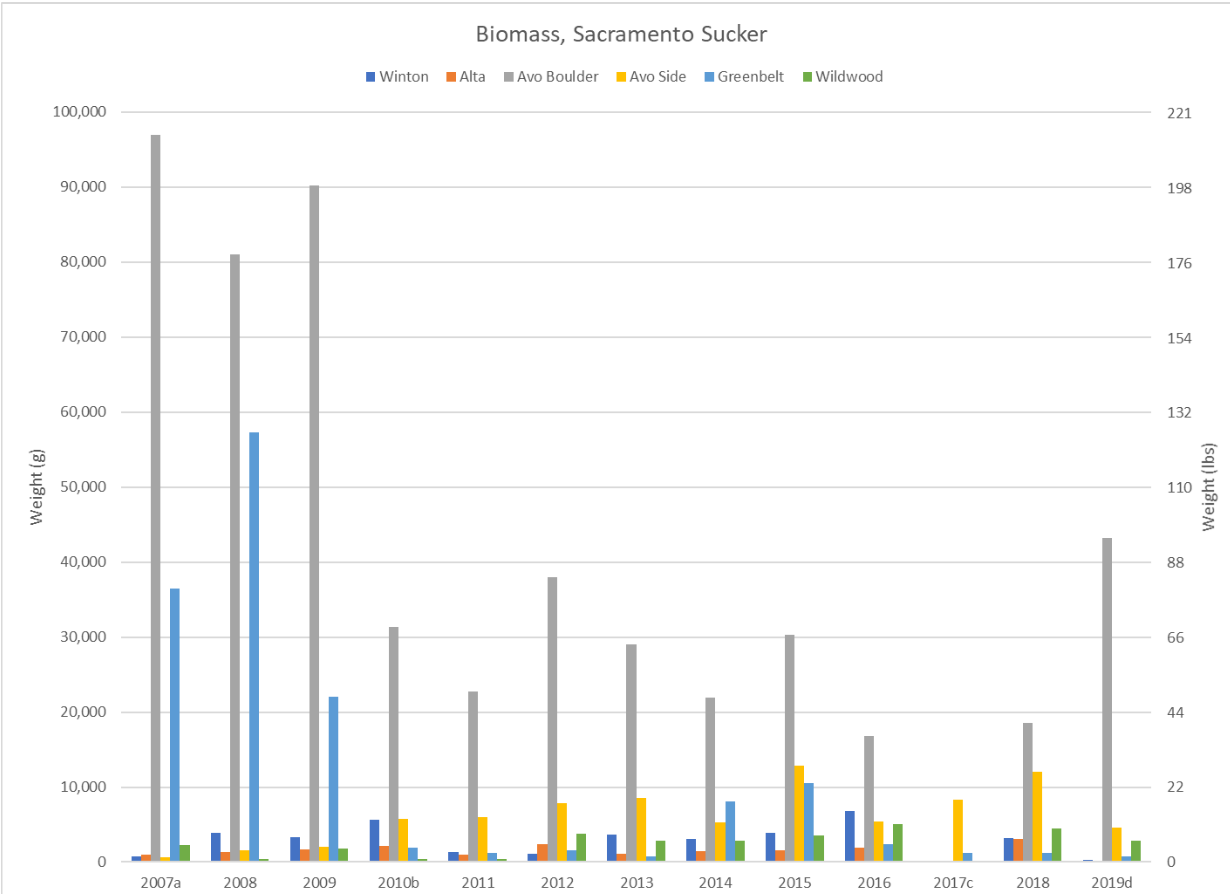

Figure 8. ***Biomass of captured Sacramento suckers per site for each Fall Population Electro-fishing Survey, 2007-2019. Note that in 2007a nine sites were sampled, and in 2010b eight sites were sampled; data shown only represents that from the six core sites sampled annually. Due to unsafe survey conditions, two sites were sampled in 2017c, and five sites in 2019d.***

Captured Sacramento suckers were most frequently juveniles, although length ranged from 1 to 34 inches (Figure 9), with 76% of captured fish smaller than 5 inches. This suggests the population consists of many young fish with a decrease in abundance as fish grow/age, which is expected in naturally occurring populations, and an indication of successful reproduction.

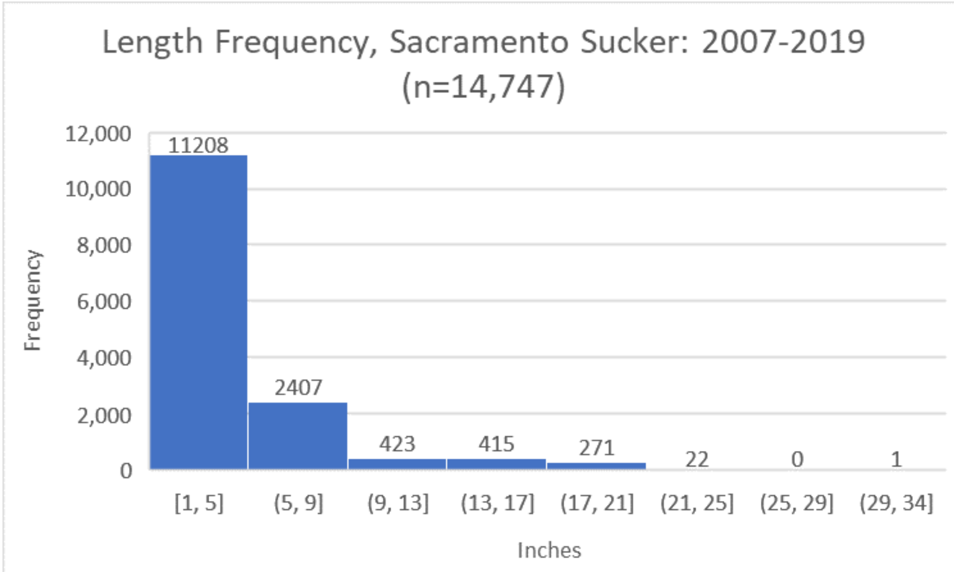

Figure 9. ***Length-frequency of Sacramento sucker captured during the Fall Population Electro-fishing Surveys, 2007-2019. The number of fish in each size class is shown.***

Centrarchidae – Sunfish, Crappie, and "Black" Bass Family

A total of 131 centrarchids, represented by 121 "black" bass, 2 bluegill, and 8 green sunfish were captured between 2007 and 2019 (Appendix B). Catch-per-unit effort for bass ranged from 0 to 7.91 fish per hour, bluegill ranged was 0 to 0.16 fish per hour, and green sunfish ranged from 0 to 0.52 fish per hour. Catch-per-unit effort for bass, bluegill, and green sunfish is provided in Appendix C. Captures of centrarchids were more likely to occur further downstream, with most captures occurring below Fresno Weir; although bass have been present at all sites, except for Winton. Additionally, centrarchids, and particularly bass, were present in greatest numbers during the drought of 2014-2016, when reductions in instream flows (Figure 1) were observed. Bluegill and green sunfish may have been more detectable on surveys during the drought period as decreased flows may have allowed them to successfully populate greater reaches of the river and/or flows and temperatures may have been more suitable. Green sunfish were however also captured in 2017, a year with extremely high instream flows (Figure 1).

Population estimates for bass ranged from 0 (95% CI, lower CI adjusted, 0-0) to 56 (95% CI, lower CI adjusted, 55-59) fish per site, bluegill ranged from 0 to 1 fish, and green sunfish ranged from 0 to 5 fish. The estimated population density of centrarchids per site varied among years, with all species undetected in some years, and bass the species primarily detected. For bass, the site with the greatest estimated population density was Greenbelt with 207 fish*ha^{-1} in 2015. This positive increase for bass in 2015 may indicate conditions in the river were conducive for bass reproduction. As a result of the drought, irrigation flows were of lesser volume and shorter duration (Figure 1) and temperatures throughout the river may have been more suitable for reproduction. Dependent on bass species, spawning typically begins in the spring when water temperatures reach 55˚F (13˚C) to 61˚F (16˚C) and continues until water temperature reaches 72˚F (22˚C) to 75˚F (24˚C) (Moyle 2002). These temperatures are not normally present in the river until near the end of the bass spawning period, but due to climatic conditions, were present by mid-March of both 2014 and 2015 (Figure 2, Figure 3). Bluegill were detected only in Greenbelt, with 3.7 fish*ha^{-1} in both 2009 and 2016. Green sunfish were detected primarily in Greenbelt, with 19 fish*ha^{-1} detected in 2017.

Fish per mile estimates for centrarchids were variable from year to year, with all species undetected in some years, and bass the species primarily detected. The highest estimated number of bass detected was in 2015, with an estimated 986 fish per mile in Greenbelt. The highest estimated number of bluegill detected was 18 fish per mile in Greenbelt in both 2009 and 2016. The highest estimated number of green sunfish detected was in Greenbelt in 2017, with 88 fish per mile.

Biomass of captured centrarchids was highly variable, with all species undetected in some years, and bass the species primarily detected. Bass have been collected at all sites except Winton. For bass, the heaviest biomass was collected in 2015 of 1.358 lbs (616 g) in Greenbelt. Bluegill were collected only in Greenbelt, with the heaviest biomass of 0.045 lbs (20 g) in 2009. Green sunfish were collected in both Winton and Greenbelt, with the highest biomass collected 0.476 lbs (216 g) in Greenbelt in 2017.

Captured centrarchids were most frequently small bass. For bass, length ranged from 2 to 11 inches, with 88% of captured fish smaller than 5 inches. Only two bluegill have been captured. The smaller bluegill, captured in 2009, was 3.98 inches (101 mm) long while the larger bluegill, captured in 2016, was 4.37 inches (111 mm) long. Eighty-eight percent of captured green sunfish were in the 4 to 6 inch range. While most captured bass were small as opposed to mature adults, this suggests a breeding population of bass are present, and they can reproduce successfully when conditions are appropriate.

Cottidae – Sculpin Family

A total of 12,434 cottids, represented in the Kings River by the prickly sculpin, riffle sculpin, and their hybrids were captured between 2007 and 2019 (Appendix B). Catch-per-unit effort is shown in Figure 10 and provided in Appendix C. Catch rate experienced a noticeable decline in all sites from 2013 through 2015, with a sharp decline at most sites in 2015, and a rebound at all sites in 2016 except Wildwood which continued to see a decline. These sharp decreases in CPUE suggest a decline in the sculpin population occurred during the drought, while increases observed in later years indicate their ability of the population to successfully recover upon conclusion of the drought in 2017.

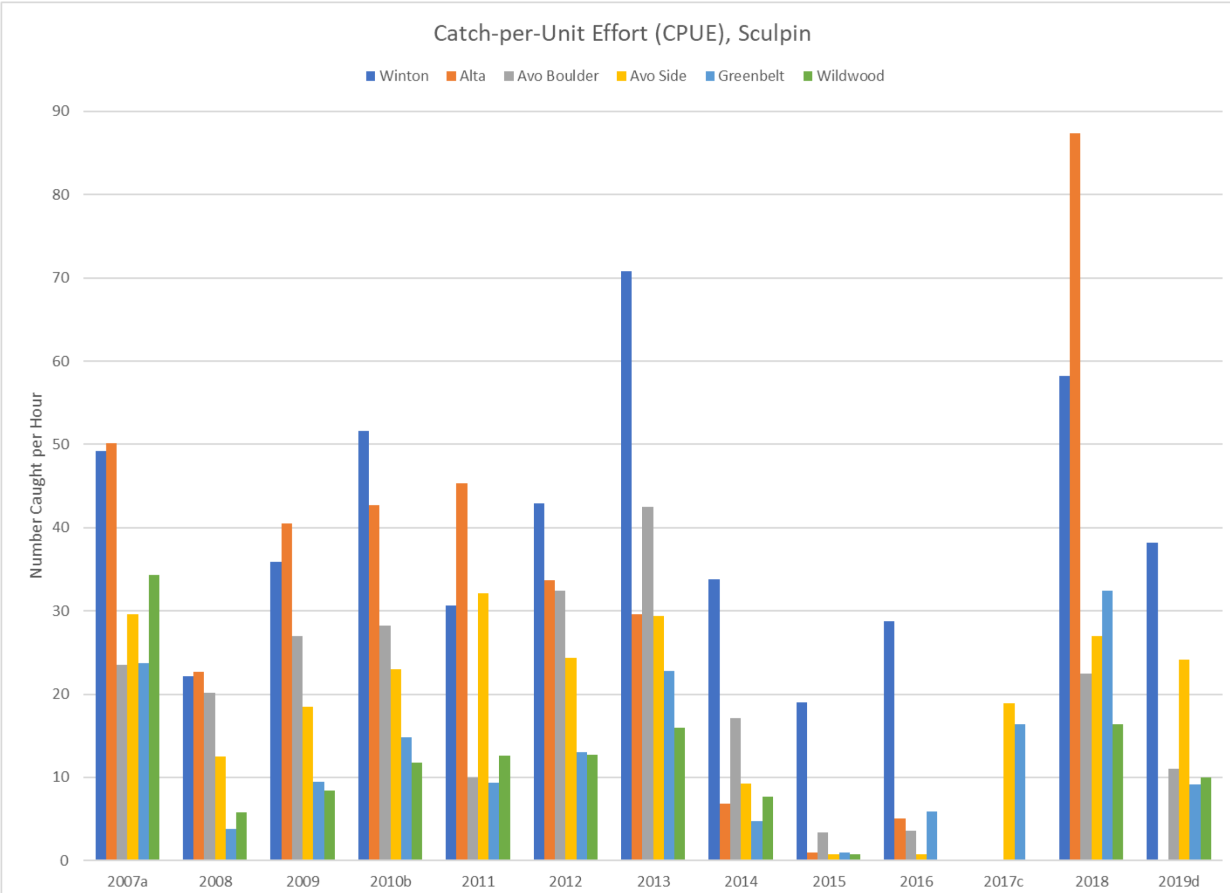

Figure 10. ***Catch-per-unit effort and number of sculpin captured per hour during the Fall Population Electro-fishing Survey, 2007-2019. Note that in 2007a nine sites were sampled, and in 2010b eight sites were sampled; data shown only represents that from the six core sites sampled annually. Due to unsafe survey conditions, two sites were sampled in 2017c, and five sites in 2019d.***

Population estimates for sculpin are summarized in Table 6 by site and year. The estimated population density per site varied among years (Figure 11). The smallest estimated population density occurred in the Wildwood site in 2016 with 4 fish*ha^{-1}. The site with the greatest estimated population density was Winton with 4,439 fish*ha^{-1} in 2018. It is unknown what contributed to the sharp decline seen in 2015. Sculpin are most abundant in cold-water (Moyle 2002). The drought which began in 2012, was at its peak in 2015, with instream flows reduced and warmer than normal temperatures in 2014 and 2015 (Figure 1, Figure 2, Figure 3). Direct mortality from temperature was unlikely as sculpin species found in the Kings River can thrive in waters which may reach temperatures of 79˚F (26˚C) (Moyle 2002). However, temperatures during the spawning period of March and April may have been a limiting factor for sculpin. Water temperatures were above the upper limit of 55˚F (13˚C) in 2014 and near the upper limit in 2015 (Figure 2, Figure 3) that are required by sculpin for successful spawning (Moyle 2002), and may have been the primary driver of the observed population decline. By 2016 March and April temperatures had returned to those suitable for spawning and an increase was seen in the population. A dip in the population was again seen from 2018 to 2019 which is consistent with the hypothesis that decreased spawning success was concurrent with slightly elevated water temperatures experienced during the 2018 spawning period (Figure 2, Figure 3).

Table 6. ***Population estimates for sculpin, 2007-2019, with 95% CI, lower CI adjusted in parenthesis, as calculated by MicroFish 3.0.***

	Population Estimate (95% CI, Lower CI Adjusted), Sculpin					
Year	**Winton**	**Alta**	**Avo Boulder**	**Avo Side**	**Greenbelt**	**Wildwood**
2007[a]	437 (403-471)	617 (530-704)	201 (179-223)	350 (228-472)	219 (210-228)	353 (271-435)
2008	176 (154-198)	175 (135-215)	147 (133-161)	73 (71-78)	29 (29-31)	58 (58-58)
2009	330 (295-365)	384 (310-458)	268 (250-286)	137 (109-166)	90 (85-97)	95 (51-183)
2010[b]	528 (483-573)	332 (293-371)	239 (205-273)	101 (96-108)	85 (78-95)	93 (87-101)
2011	326 (276-376)	229 (216-242)	87 (85-91)	159 (145-173)	259 (60-1,068)	150 (93-224)
2012	372 (350-394)	469 (427-511)	302 (283-321)	214 (188-240)	130 (104-158)	125 (99-154)
2013	540 (516-564)	191 (188-195)	307 (295-319)	215 (193-237)	195 (179-211)	152 (131-173)
2014	395 (374-416)	61 (54-72)	141 (129-154)	107 (81-139)	36 (34-41)	63 (59-70)
2015	164 (160-170)	10 (10-10)	27 (27-29)	8 (4-50)	7 (7-9)	6 (6-10)
2016	230 (214-246)	30 (27-38)	26 (24-32)	4 (4-5)	37 (37-39)	1 (1-1)
2017[c]	-	-	-	172 (152-192)	163 (156-171)	-
2018	877 (812-942)	799 (737-861)	156 (142-170)	209 (179-239)	261 (244-278)	165 (145-185)
2019[d]	455 (386-524)	-	68 (67-71)	214 (176-252)	71 (69-75)	144 (68-291)

a = nine sites sampled, but data shown represents only that from the six core sites sampled annually

b = eight sites sampled, but data shown represents only that from the six core sites sampled annually

c = only two sites sampled due to unsafe flows for surveying at other sites

d = only five sites sampled due to adverse weather at Alta creating unsafe survey conditions

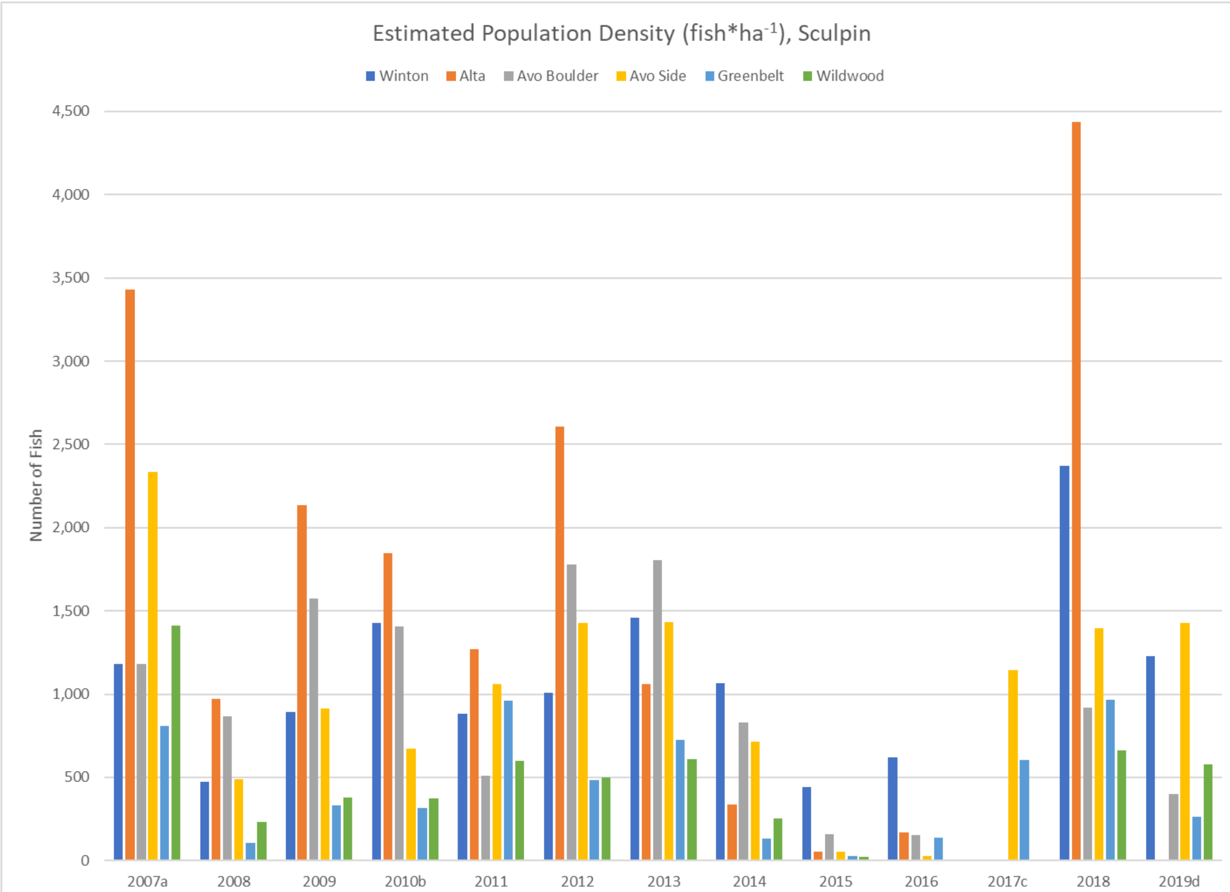

Figure 11. ***Estimated population density of sculpin per site during the Fall Population Electro-fishing Survey, 2007-2019. Note that in 2007a nine sites were sampled, and in 2010b eight sites were sampled; data shown only represents that from the six core sites sampled annually. Due to unsafe survey conditions, two sites were sampled in 2017c, and five sites in 2019d.***

Fish per mile estimates fluctuated from year to year, with notable decreases observed beginning in 2014 and extending through 2016. The lowest estimated number of sculpin per mile occurred in 2016 at 18 fish per mile in Wildwood, and the highest estimated number at 15,435 fish per mile at Winton in 2018 (Figure 12).

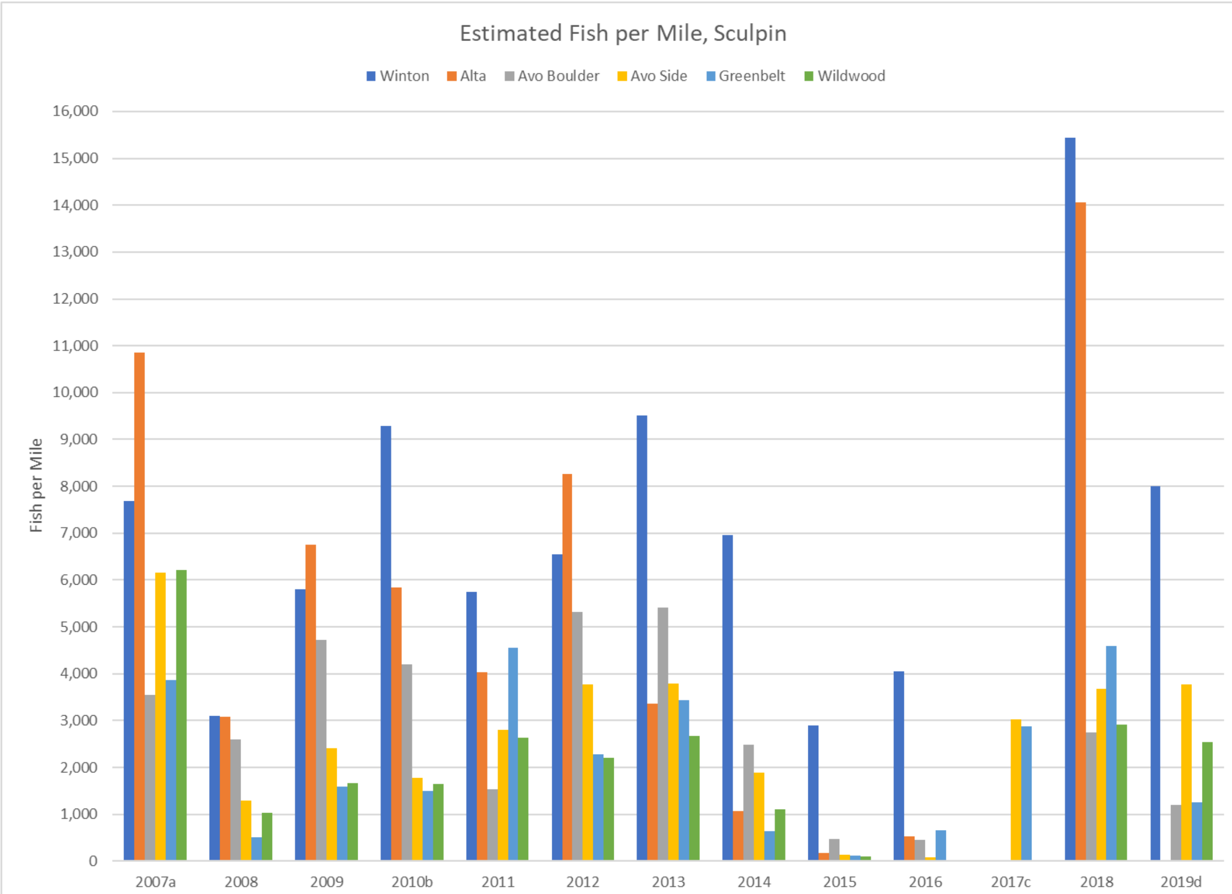

Figure 12. ***Estimated number of fish per mile for sculpin per site during the Fall Population Electro-fishing Survey, 2007-2019. Note that in 2007a nine sites were sampled, and in 2010b eight sites were sampled; data shown only represents that from the six core sites sampled annually. Due to unsafe survey conditions, two sites were sampled in 2017c, and five sites in 2019d.***

Biomass of captured sculpin was highly variable. The lowest biomass captured was 0.3 lbs (17 g) in Wildwood in 2016, and the heaviest biomass was 9.7 pounds (4,380 g) in Winton in 2018 (Figure 13). The Winton site is the furthest upstream, and consistently provides some of the highest biomass numbers for sculpin of the sites sampled. This may be an indication habitat factors in this site are more suitable than other sites, particularly those furthest downstream, Greenbelt and Wildwood, which typically have lower biomass numbers than any other site upstream.

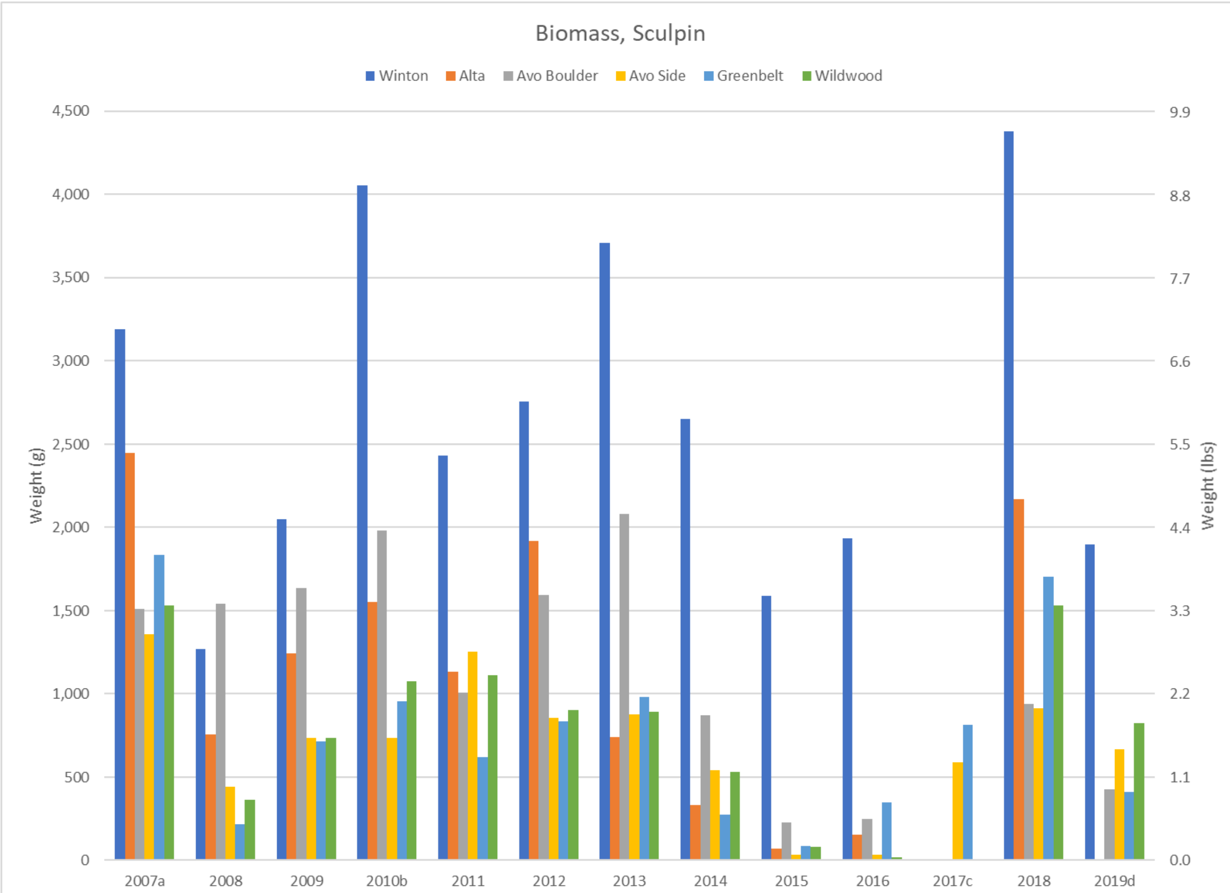

Figure 13. ***Biomass of captured sculpin per site for each Fall Population Electro-fishing Survey, 2007-2019. Note that in 2007a nine sites were sampled, and in 2010b eight sites were sampled; data shown only represents that from the six core sites sampled annually. Due to unsafe survey conditions, two sites were sampled in 2017c, and five sites in 2019d.***

Captured sculpin ranged in length from 1 to 7 inches (Figure 14). Twenty-six percent of captured fish were smaller than 3 inches and 94% were smaller than 4 inches. Based on size class, the bulk of sculpin captured were probably at least two years of age and would have been reproductively mature. Two-year-old sculpin are generally 1.6 (40 mm) to 2 inches (50 mm) long and breed at the end of their second year (Moyle 2002). Young-of-the-year sculpin may have been present but missed during electro-fishing sampling as their small size may cause them to be undetected, consumed by other piscivorous fish while in the holding container, or evade capture by slipping through the netting mesh.

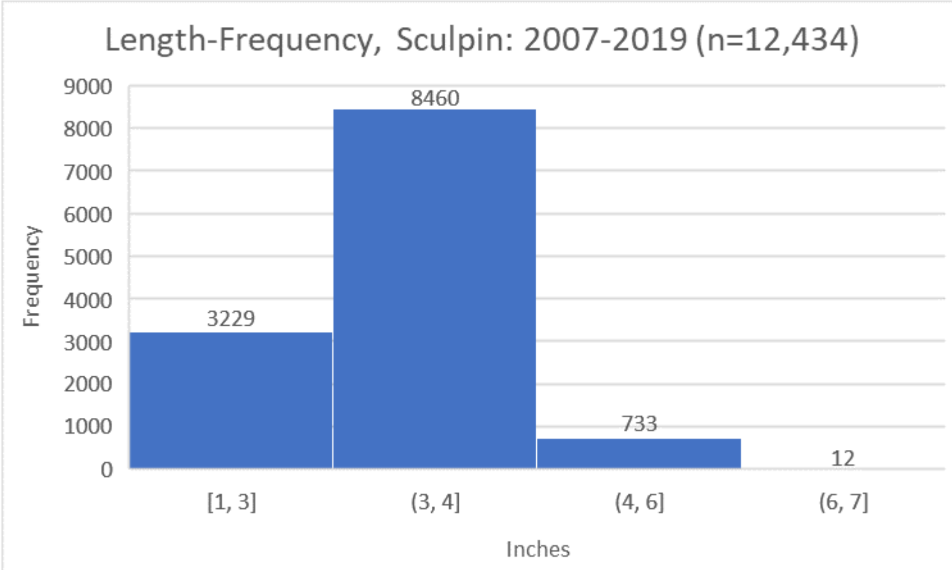

Figure 14. ***Length-frequency of sculpin captured during the Fall Population Electro-fishing Surveys, 2007-2019. The number of fish in each size class is shown.***

Cyprinidae – Minnow Family

A total of 15,608 cyprinids, represented by 8,733 California roach, 1 hardhead, and 6,874 Sacramento pikeminnow were captured between 2007 and 2019 (Appendix B). Catch-per-unit effort for California roach is shown in Figure 15. Catch-per-unit effort for hardhead, captured only in Greenbelt in 2018, was 0.14 fish per hour. Catch-per-unit effort for Sacramento pikeminnow is shown in Figure 16. Annual CPUE for California roach, hardhead, and Sacramento pikeminnow is provided in Appendix C. Catch-per-unit effort for California roach showed an increase in all sites during the 2012-2016 drought. This may have been due to favorable habitat conditions created by the drought which aided survival. The Wildwood site, which is the furthest downstream, in most years had the highest catch rates of all sites, suggesting this site is best suited for California Roach than others which are sampled. Hardhead, which were captured in only one year, may be underrepresented in the thirteen years sampling occurred. Small minnows can be difficult to distinguish when they are less than a couple of inches long and it is possible that hardhead have been misidentified in the past. The distinguishing feature which separates hardhead from other native minnows in the Kings River is the presence of a frenum, a bridge of skin between the upper jaw and head.

The frenum is readily visible when the jaw is opened, although may be difficult to distinguish in very small fish and has not always been checked by those processing captured fish. For Sacramento pikeminnow the catch-per-unit effort was highest in the drought years of 2007-2008, and 2012-2016 at most sites. An increase in CPUE was observed at all sites at the beginning of the drought in 2012, with a gradual decline following conclusion of the drought in 2017. It is unknown if this increase was due to favorable conditions created by the drought or other factors.

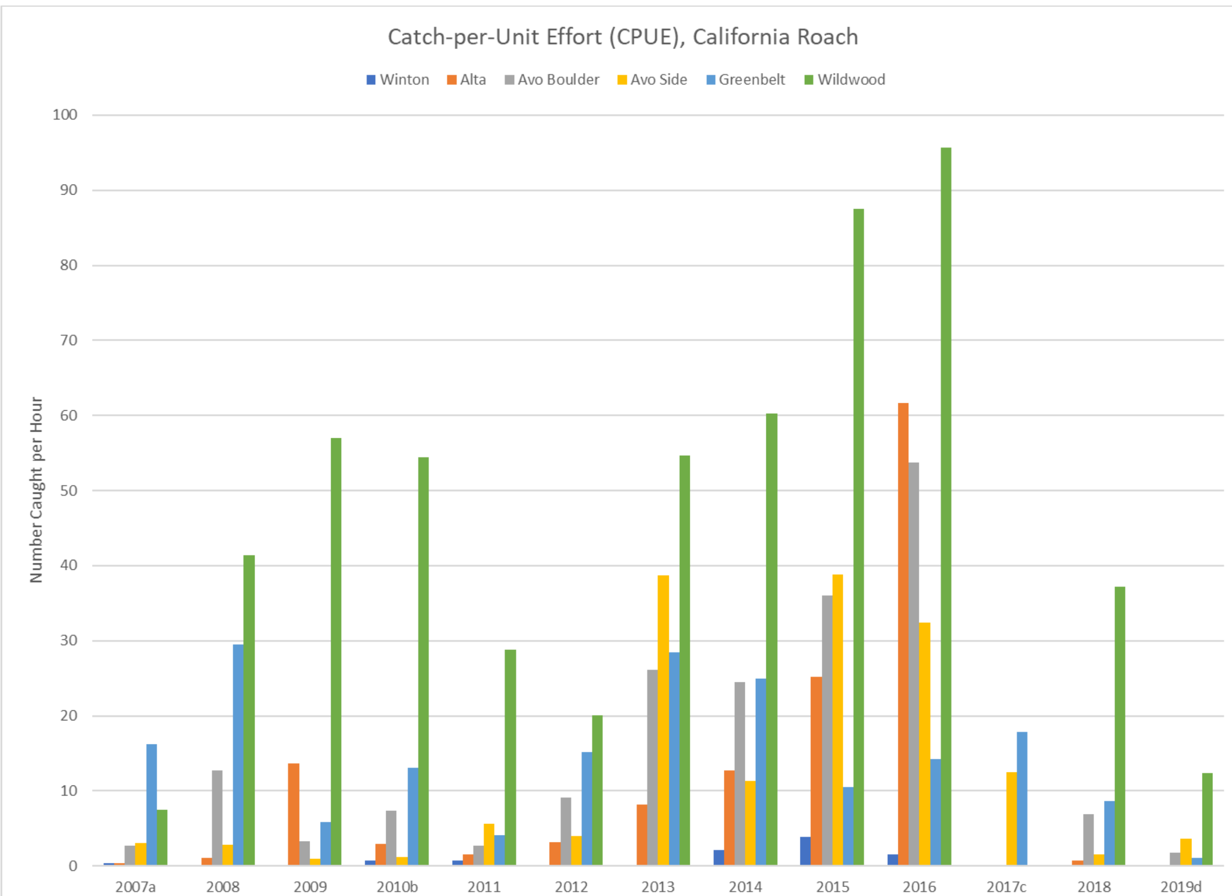

Figure 15. ***Catch-per-unit effort and number of California roach captured per hour during the Fall Population Electro-fishing Survey, 2007-2019. Note that in 2007a nine sites were sampled, and in 2010b eight sites were sampled; data shown only represents that from the six core sites sampled annually. Due to unsafe survey conditions, two sites were sampled in 2017c, and five sites in 2019d.***

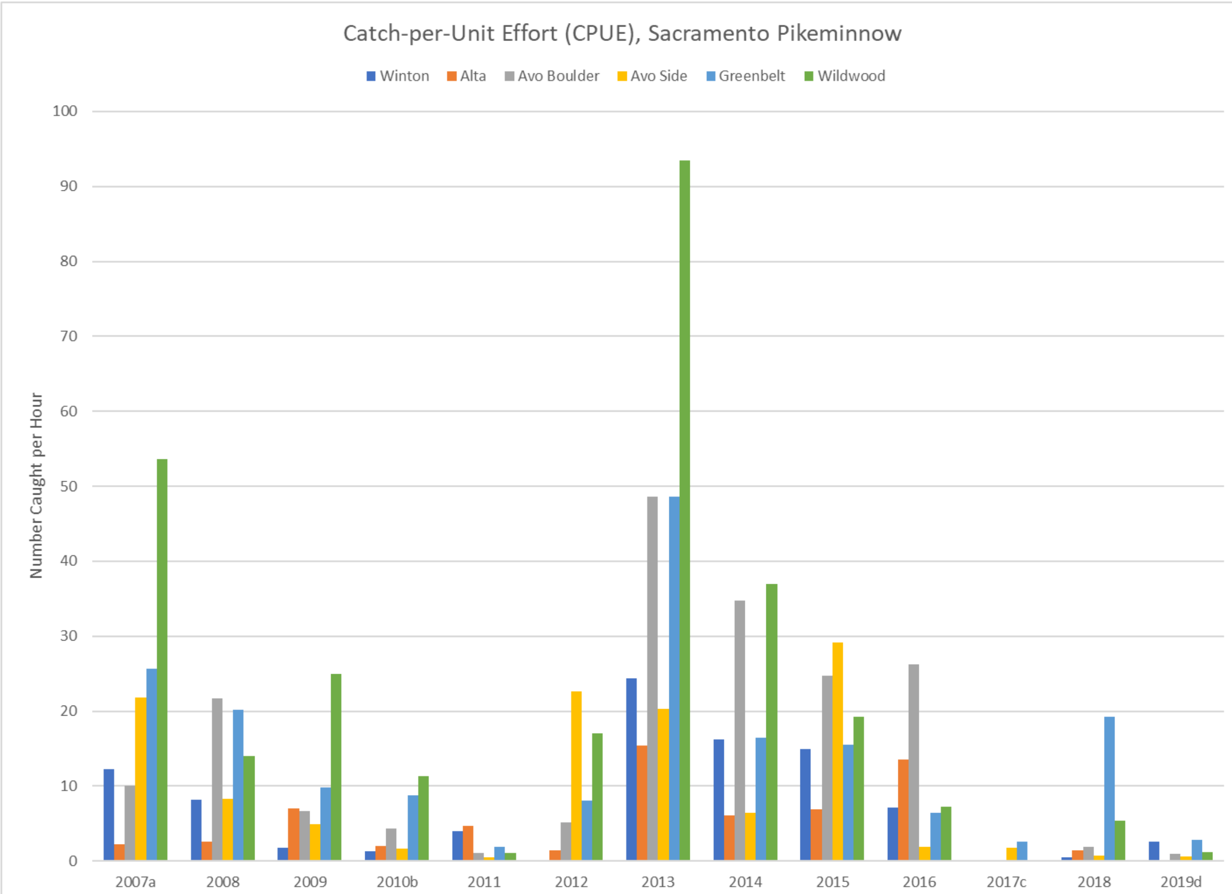

Figure 16. ***Catch-per-unit effort and number of Sacramento pikeminnow captured per hour during the Fall Population Electro-fishing Survey, 2007-2019. Note that in 2007a nine sites were sampled, and in 2010b eight sites were sampled; data shown only represents that from the six core sites sampled annually. Due to unsafe survey conditions, two sites were sampled in 2017c, and five sites in 2019d.***

Population estimates for California roach are summarized in Table 7 by site and year. For hardhead, the population was estimated at 1 (95% CI, lower CI adjusted, (1-1) in Greenbelt in 2018, the only site and year hardhead was captured. Population estimates for Sacramento pikeminnow are summarized in Table 8. The estimated population density of cyprinids varied among years, with hardhead detectable in only one year, and California roach and Sacramento Pikeminnow detectable each year, although California roach were not always detectable within a site. In 2015, the site with the greatest estimated population density was Wildwood with 4,240 fish*ha^{-1} (Figure 17). The California roach population has largely remained steady in the Wildwood site with an increase during the 2012-2016 drought.

Hardhead were detected only at Greenbelt in 2018, with an estimated population density of 4 fish*ha^{-1}. This may not accurately reflect the hardhead population present in the Kings River. Reports from anglers indicate they are captured with some regularity in several locations below Fresno Weir, suggesting a limited distribution within the river. While misidentification may in part account for the lack of hardhead detected, habitat in survey sites may not be suitable for hardhead. Hardhead prefer deep pools and runs with a mix of sand, gravel, boulder substrate and low velocity (Moyle 2002), features which may not be present or in sufficient composition to support hardhead in sample sites. For Sacramento pikeminnow, the site with the smallest estimated population density occurred in Winton in 2012 with 3 fish*ha^{-1}; in 2007, the site with the greatest estimated population density was Wildwood, with 5,764 fish*ha^{-1} (Figure 18). In all thirteen years of the survey period covered in this report, cyprinids have generally occurred in greatest numbers below Fresno Weir. Habitat conditions and the warmer temperatures found in the summer and late fall due to the distance downstream from the dam may be more favorable for the life histories of these species. California roach can tolerate temperatures up to 95˚F (35˚C) while Sacramento pikeminnow can tolerate temperatures up to 82˚F (28˚C).

Table 7. ***Population estimates for California Roach, 2007-2019, with 95% CI, lower CI adjusted in parenthesis, as calculated by MicroFish 3.0.***

Population Estimate (95% CI, Lower CI Adjusted), California Roach						
Year	**Winton**	**Alta**	**Avo Boulder**	**Avo Side**	**Greenbelt**	**Wildwood**
2007[a]	3 (3-3)	3 (3-3)	20 (20-21)	82 (22-437)	177 (146-208)	57 (53-64)
2008	0 (0-0)	6 (6-8)	126 (126-126)	46 (16-211)	253 (233-273)	504 (317-691)
2009	0 (0-0)	150 (93-224)	45 (45-45)	6 (6-7)	58 (52-68)	440 (386-494)
2010[b]	6 (6-7)	22 (19-31)	79 (51-127)	5 (5-6)	75 (69-84)	564 (473-655)
2011	18 (6-140)	7 (7-7)	24 (23-28)	39 (25-75)	41 (26-79)	390 (220-560)
2012	0 (0-0)	39 (37-44)	116 (116-116)	45 (45-45)	146 (121-171)	514 (156-1203)
2013	0 (0-0)	54 (52-58)	198 (182-214)	263 (251-275)	297 (240-354)	479 (459-499)
2014	26 (23-34)	152 (152-152)	255 (196-314)	104 (100-110)	240 (189-291)	522 (492-552)
2015	34 (33-38)	189 (183-196)	350 (314-386)	253 (222-284)	113 (73-170)	1060 (914-1,206)
2016	11 (11-12)	376 (347-405)	491 (414-568)	283 (167-399)	114 (89-143)	922 (748-1,096)
2017[c]	-	-	-	118 (99-139)	197 (174-220)	-
2018	0 (0-0)	6 (5-15)	70 (44-120)	11 (10-16)	96 (96-96)	513 (385-641)
2019[d]	0 (0-0)	-	12 (11-18)	105 (25-601)	10 (8-21)	154 (84-261)

a = nine sites sampled, but data shown represents only that from the six core sites sampled annually

b = eight sites sampled, but data shown represents only that from the six core sites sampled annually

c = only two sites sampled due to unsafe flows for surveying at other sites

d = only five sites sampled due to adverse weather at Alta creating unsafe survey conditions

Table 8. ***Population estimates for Sacramento pikeminnow, 2007-2019, with 95% CI, lower CI adjusted in parenthesis, as calculated by MicroFish 3.0.***

Population Estimate (95% CI, Lower CI Adjusted), Sacramento Pikeminnow						
Year	**Winton**	**Alta**	**Avo Boulder**	**Avo Side**	**Greenbelt**	**Wildwood**
2007[a]	113 (93-136)	27 (20-46)	112 (112-112)	170 (157-183)	381 (248-514)	1,441 (378-2,952)
2008	91 (56-151)	15 (15-17)	389 (143-800)	53 (47-63)	160 (154-167)	141 (141-141)
2009	14 (14-15)	65 (48-93)	154 (60-385)	31 (29-37)	114 (88-145)	181 (155-207)
2010[b]	14 (11-26)	13 (13-15)	40 (30-62)	7 (7-9)	59 (46-81)	108 (83-138)
2011	50 (50-50)	23 (22-27)	10 (9-16)	2 (2-7)	18 (18-18)	8 (8-10)
2012	1 (1-1)	21 (17-33)	46 (44-51)	254 (254-254)	69 (64-77)	531 (133-1,533)
2013	239 (179-299)	164 (98-250)	370 (347-393)	183 (130-236)	1,255 (375-2,630)	908 (851-965)
2014	214 (181-247)	55 (48-67)	324 (282-366)	86 (86-86)	150 (117-183)	329 (300-358)
2015	141 (126-156)	247 (50-1,250)	501 (200-893)	185 (162-208)	175 (108-256)	161 (158-166)
2016	78 (78-78)	78 (72-87)	232 (185-279)	10 (10-11)	56 (40-86)	66 (66-66)
2017[c]	-	-	-	25 (14-69)	29 (25-39)	-
2018	6 (6-8)	14 (11-26)	27 (12-105)	5 (5-8)	156 (142-170)	59 (47-79)
2019[d]	59 (23-205)	-	8 (6-22)	8 (4-50)	22 (21-26)	9 (8-15)

a = nine sites sampled, but data shown represents only that from the six core sites sampled annually

b = eight sites sampled, but data shown represents only that from the six core sites sampled annually

c = only two sites sampled due to unsafe flows for surveying at other sites

d = only five sites sampled due to adverse weather at Alta creating unsafe survey conditions

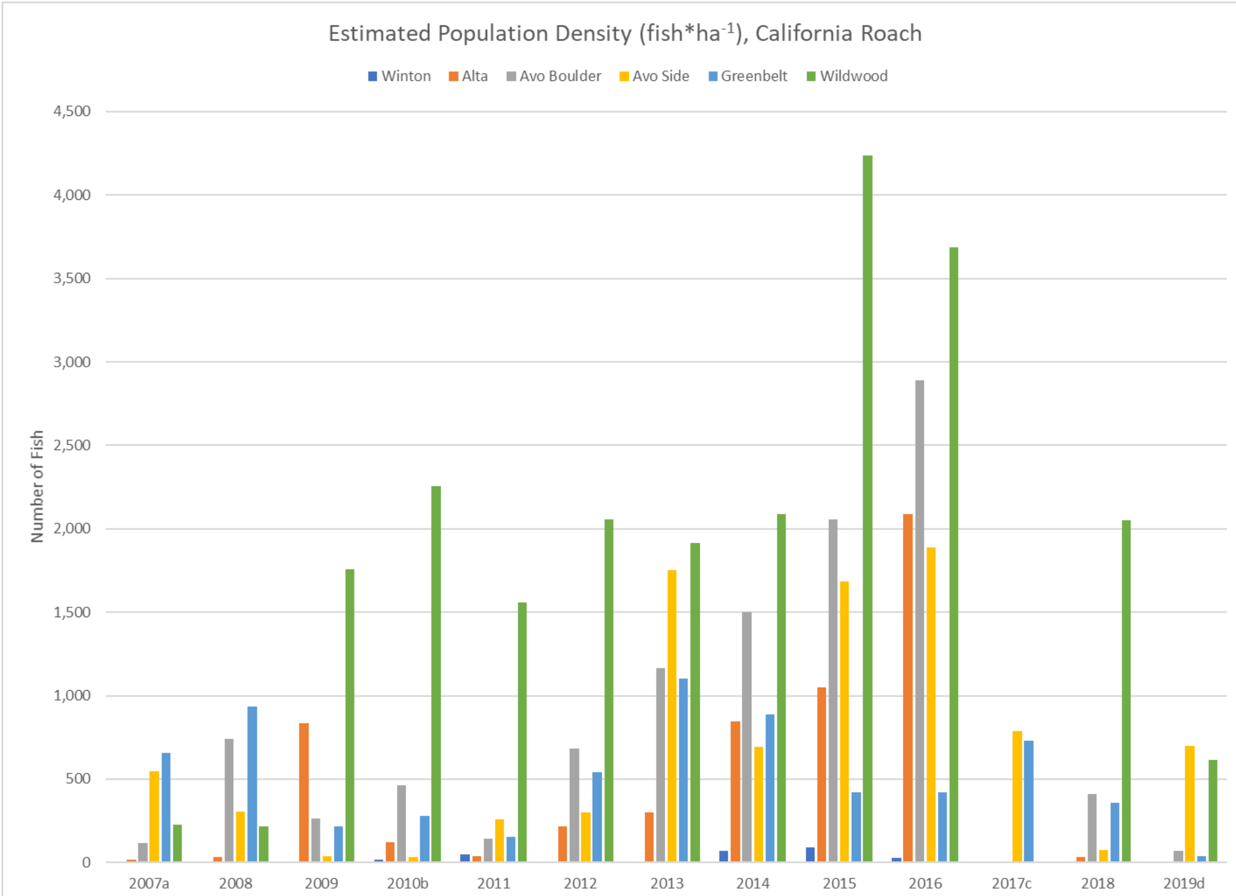

Figure 17. ***Estimated population density of California roach per site during the Fall Population Electro-fishing Survey, 2007-2019. Note that in 2007a nine sites were sampled, and in 2010b eight sites were sampled; data shown only represents that from the six core sites sampled annually. Due to unsafe survey conditions, two sites were sampled in 2017c, and five sites in 2019d.***

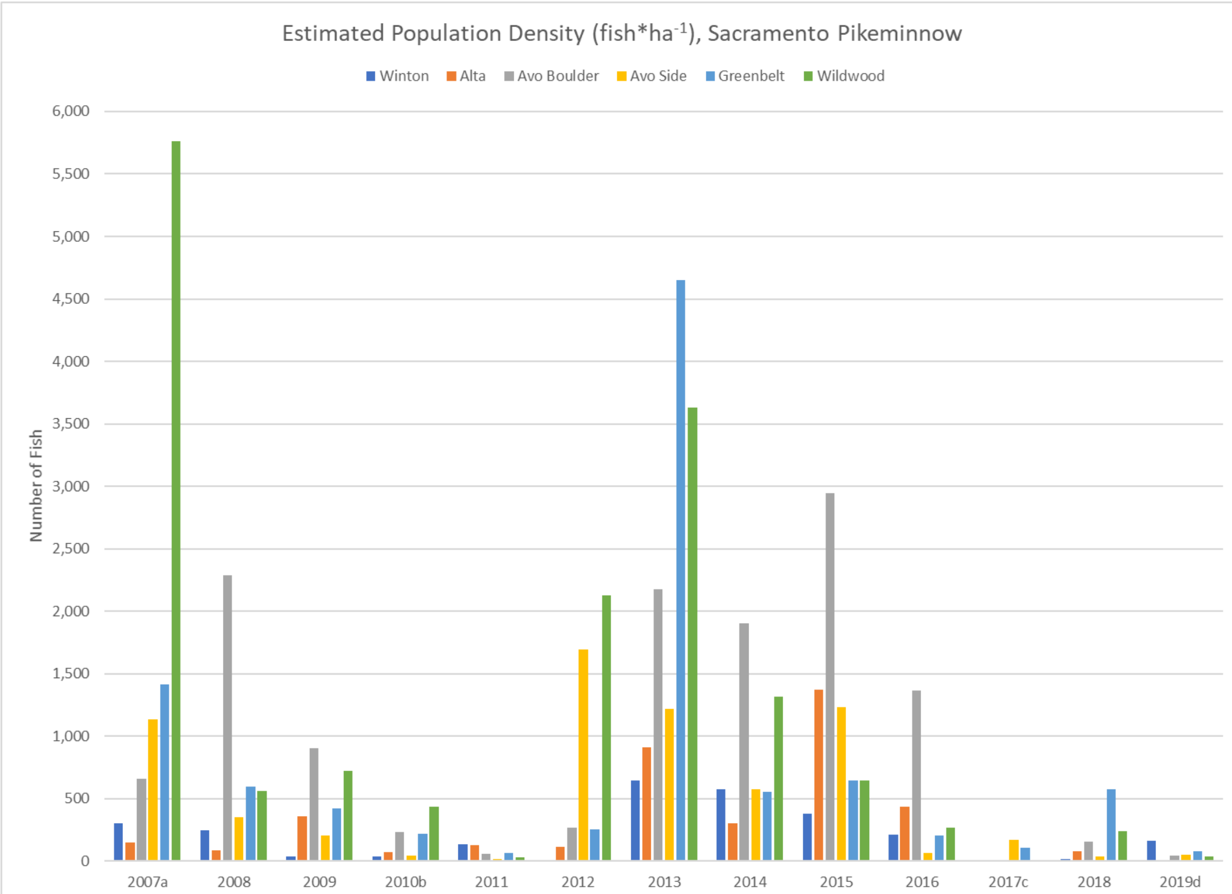

Figure 18. ***Estimated population density of Sacramento pikeminnow per site during the Fall Population Electro-fishing Survey, 2007-2019. Note that in 2007a nine sites were sampled, and in 2010b eight sites were sampled; data shown only represents that from the six core sites sampled annually. Due to unsafe survey conditions, two sites were sampled in 2017c, and five sites in 2019d.***

Fish per mile estimates were variable for cyprinids from year to year, with hardhead only detected in one year. California roach have been detected in all sites except Winton in some years. The highest estimated number of California roach occurred in Wildwood in 2015 at 18,656 fish per mile (Figure 19). For the only detection of a hardhead, in Greenbelt in 2018, 18 fish per mile was estimated. The lowest estimated number of Sacramento pikeminnow occurred in 2012 in Winton at 18 fish per mile, and the highest estimated number in Wildwood in 2007 at 25,362 fish per mile (Figure 20).

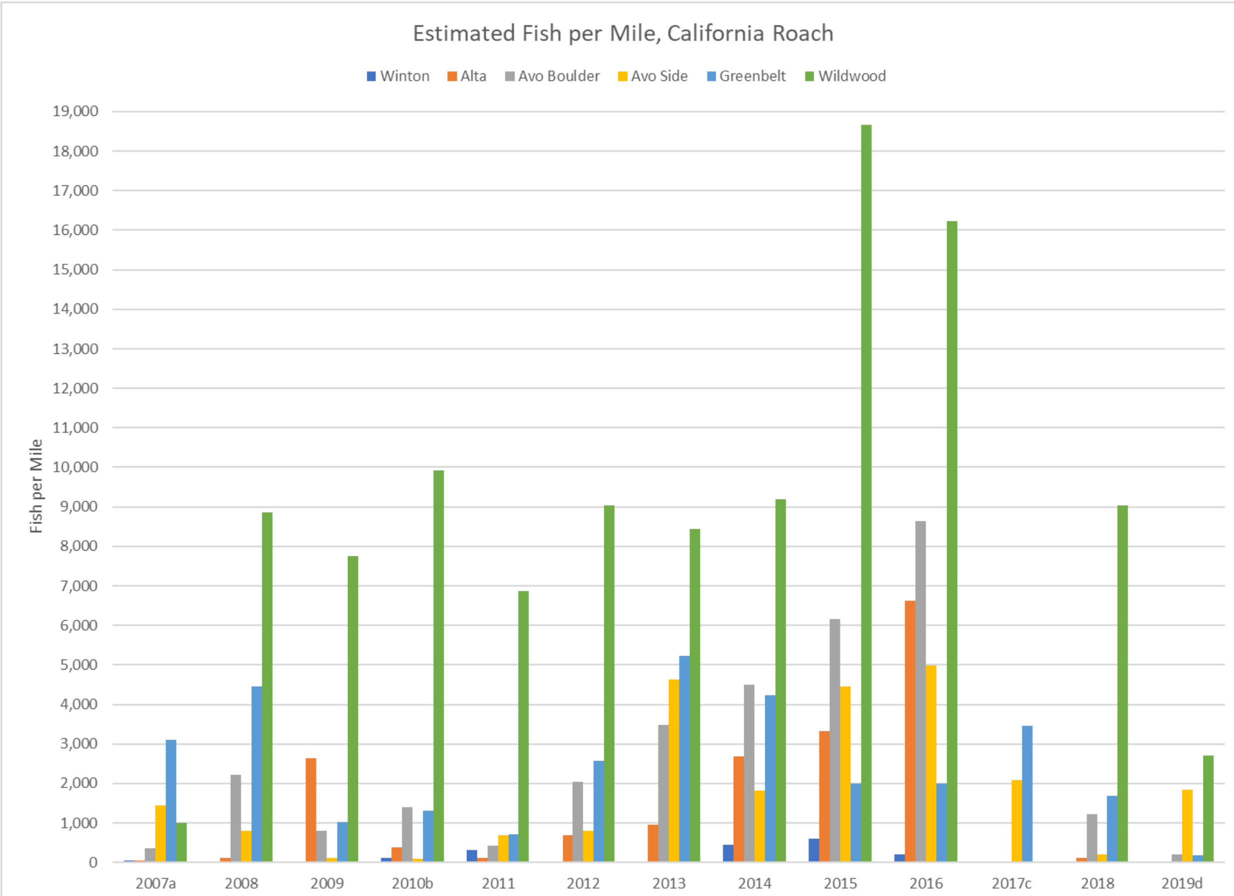

Figure 19. ***Estimated number of fish per mile for California roach per site during the Fall Population Electro-fishing Survey, 2007-2019. Note that in 2007a nine sites were sampled, and in 2010b eight sites were sampled; data shown only represents that from the six core sites sampled annually. Due to unsafe survey conditions, two sites were sampled in 2017c, and five sites in 2019d.***

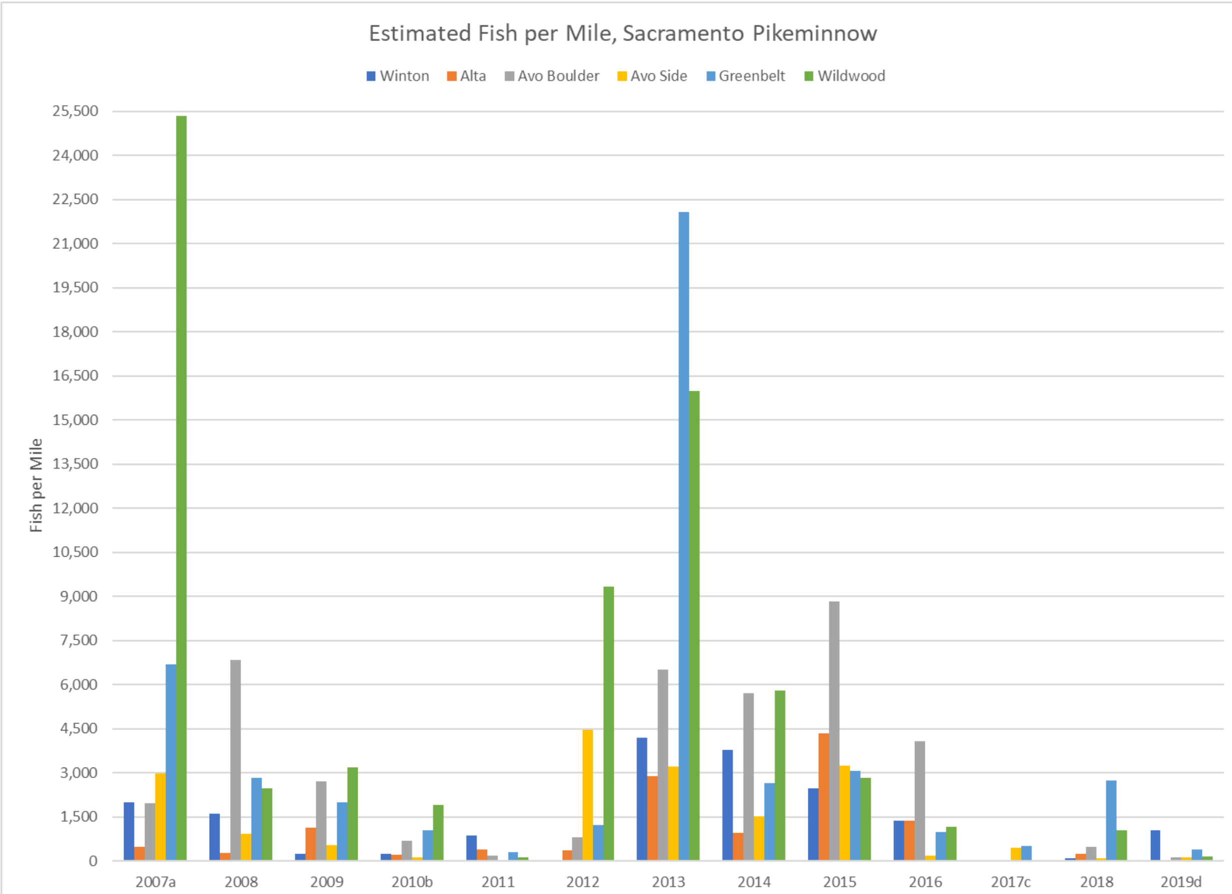

Figure 20. ***Estimated number of fish per mile for Sacramento pikeminnow per site during the Fall Population Electro-fishing Survey, 2007-2019. Note that in 2007a nine sites were sampled, and in 2010b eight sites were sampled; data shown only represents that from the six core sites sampled annually. Due to unsafe survey conditions, two sites were sampled in 2017c, and five sites in 2019d.***

Biomass of captured cyprinids varied between years, with California roach and Sacramento pikeminnow regularly detected. California roach have been captured at all sites except Winton in 6 of the 12 years that site has been sampled, with the heaviest biomass of California roach collected was 4.4 lbs (2,002 g) from Wildwood in 2015 (Figure 21). In the singular detection of a hardhead in Greenbelt in 2018, 0.03 lbs (13 g) was recorded. The lowest biomass of captured Sacramento pikeminnow, 0.003 lbs (1 g) was collected from Winton in 2012, and the heaviest biomass was 10 lbs (4,532 g) from Avo Boulder in 2008 (Figure 22). Biomass of cyprinids increased during the 2012-2016 drought, suggesting conditions were favorable for growth and survival. While biomass was typically highest in the Wildwood site for California roach across all years, increases were seen in other sites during the drought, most notably Avo Boulder, Avo Side, and Greenbelt. For Sacramento pikeminnow, biomass was highest in the Avo Boulder site in all years sampled. Larger Sacramento pikeminnow were most frequently observed in this site and it may contain habitat more suitable for larger pikeminnow than other sites, however habitat data is unavailable for sample sites. In all sites biomass saw an increase during the early years of the 2012-2016 drought, with the Wildwood site seeing a large increase in 2013 before gradually tapering off to pre-drought levels. This may indicate that the shallow waters present provided suitable habitat for smaller pikeminnow or an increase in spawning success concurrent with the drought as population density was also increased in those sites during those same years.

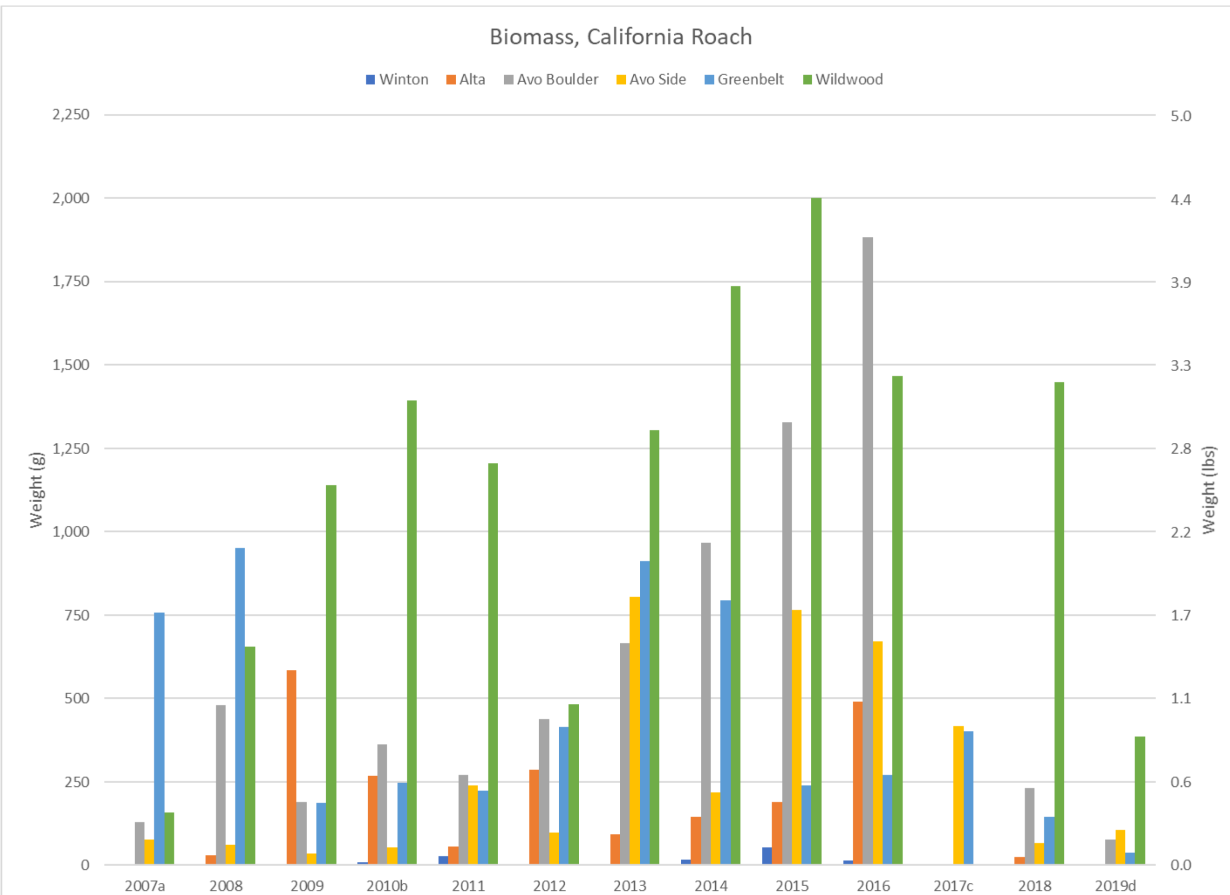

Figure 21. ***Biomass of captured California roach per site for each Fall Population Electro-fishing Survey, 2007-2019. Note that in 2007a nine sites were sampled, and in 2010b eight sites were sampled; data shown only represents that from the six core sites sampled annually. Due to unsafe survey conditions, two sites were sampled in 2017c, and five sites in 2019d.***

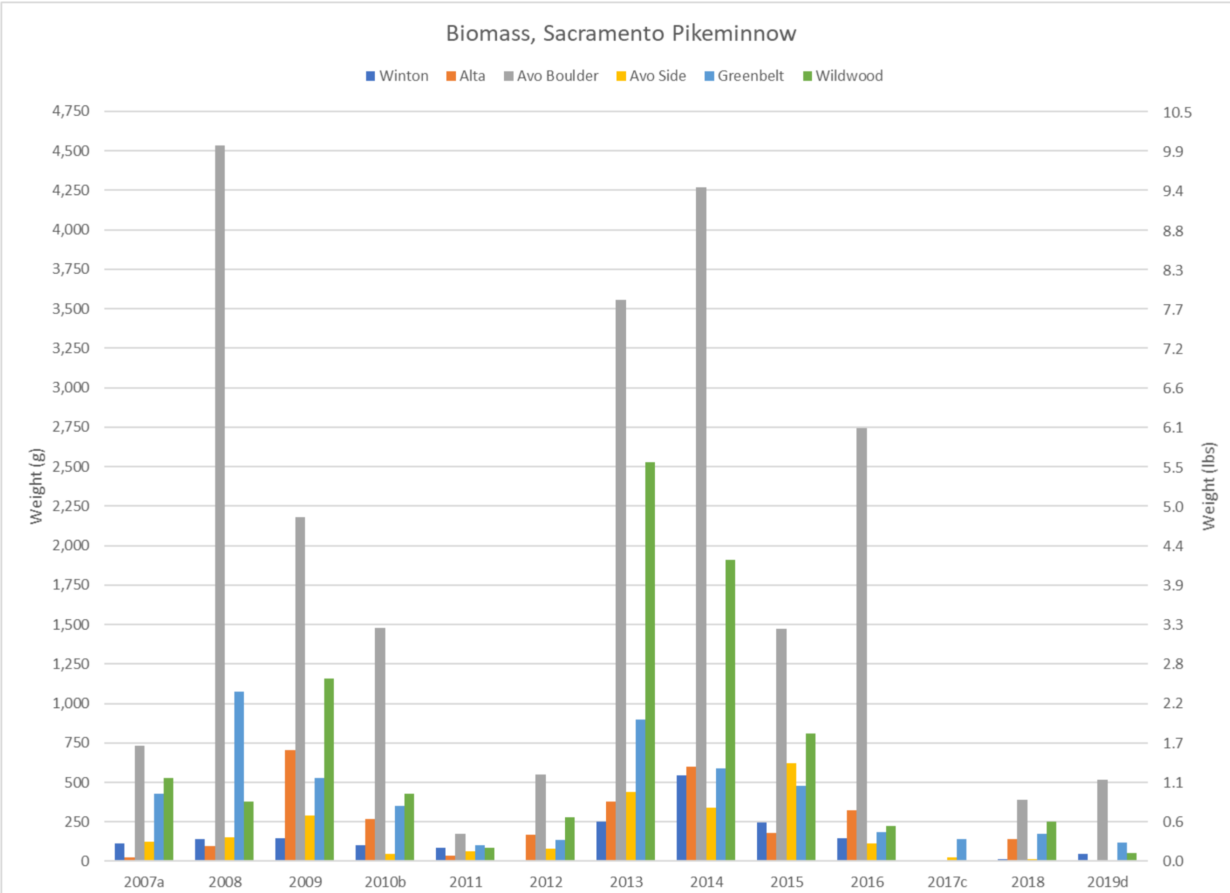

Figure 22. ***Biomass of captured Sacramento pikeminnow per site for each Fall Population Electro-fishing Survey, 2007-2019. Note that in 2007a nine sites were sampled, and in 2010b eight sites were sampled; data shown only represents that from the six core sites sampled annually. Due to unsafe survey conditions, two sites were sampled in 2017c, and five sites in 2019d.***

Captured cyprinids were most frequently California roach or small Sacramento pikeminnow. For California roach, length ranged from 1 to 7 inches (Figure 23), with 22% of captured fish smaller than 2 inches and 91% smaller than 4 inches. The only hardhead, captured in 2018, measured 4.76 inches (121 mm). For Sacramento pikeminnow, length ranged from 1 to 19 inches (Figure 24), with 82% of captured fish smaller than 4 inches, and 97% smaller than 6 inches. For California Roach, juveniles made up 22% of the capture. Maturity is usually reached at the end of the second year when California roach are 2 inches long (45 mm) (Moyle 2002). Juvenile roach may be poorly represented in the capture data. Due to their small size, they may be able to slip through the mesh of nets and thus avoid capture. For Sacramento pikeminnow, length-frequency analysis indicates juveniles are more numerous than adults, as would be expected in a natural population. Sacramento pikeminnow are long-lived and slow growing, maturity is reached at the end of their third or fourth year at a length of 9 inches (220 mm); upon reaching a length of 8 inches their diet becomes almost exclusively piscivorous (Moyle 2002).

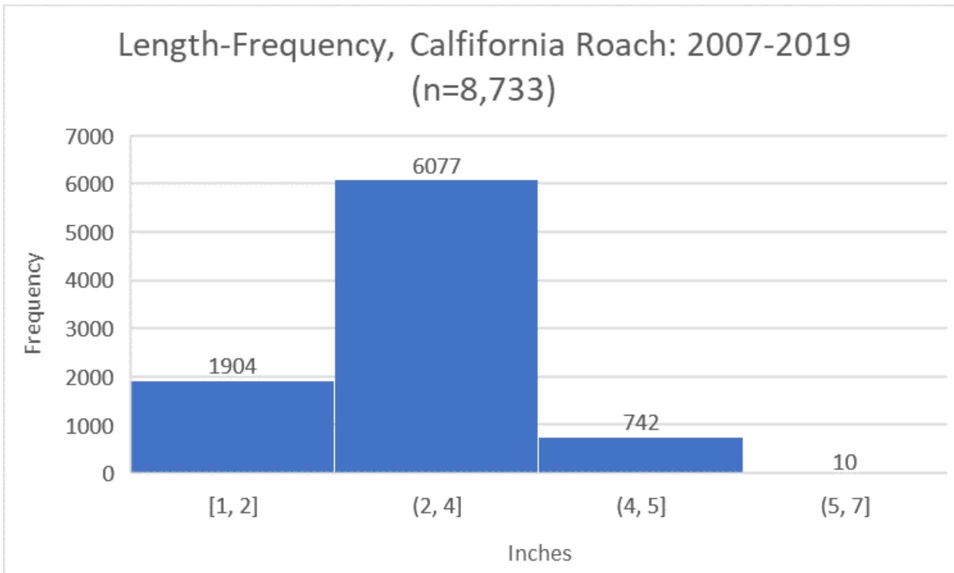

Figure 23. ***Length-frequency of California roach captured during the Fall Population Electro-fishing Surveys, 2007-2019. The number of fish in each size class is shown.***

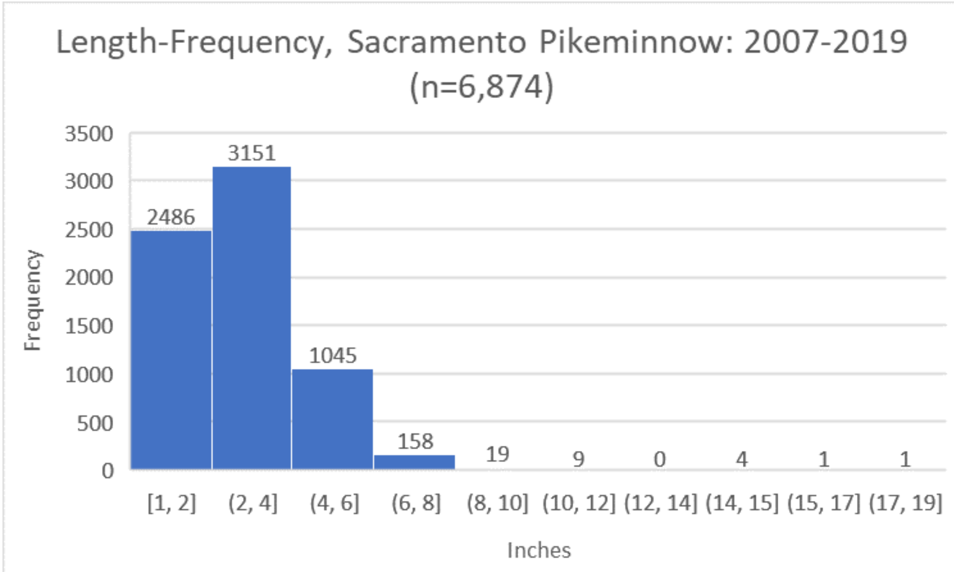

Figure 24. ***Length-frequency of Sacramento pikeminnow captured during the Fall Population Electro-fishing Surveys, 2007-2019. The number of fish in each size class is shown.***

Gasterosteidae – Stickleback Family

A total of 2,071 gasterosteids, represented by the three-spine stickleback were captured between 2007 and 2019 (Appendix B). Catch-per-unit effort is shown in Figure 25 and provided in Appendix C. Capture rates for stickleback have been largely consistent over the years, with Alta and Wildwood typically producing the highest CPUE rates. Increases were seen during the 2012-2016 drought in most sites, particularly in 2016. It is unknown if this was due to an increase in the population and thus detectability in those years or some other factor.

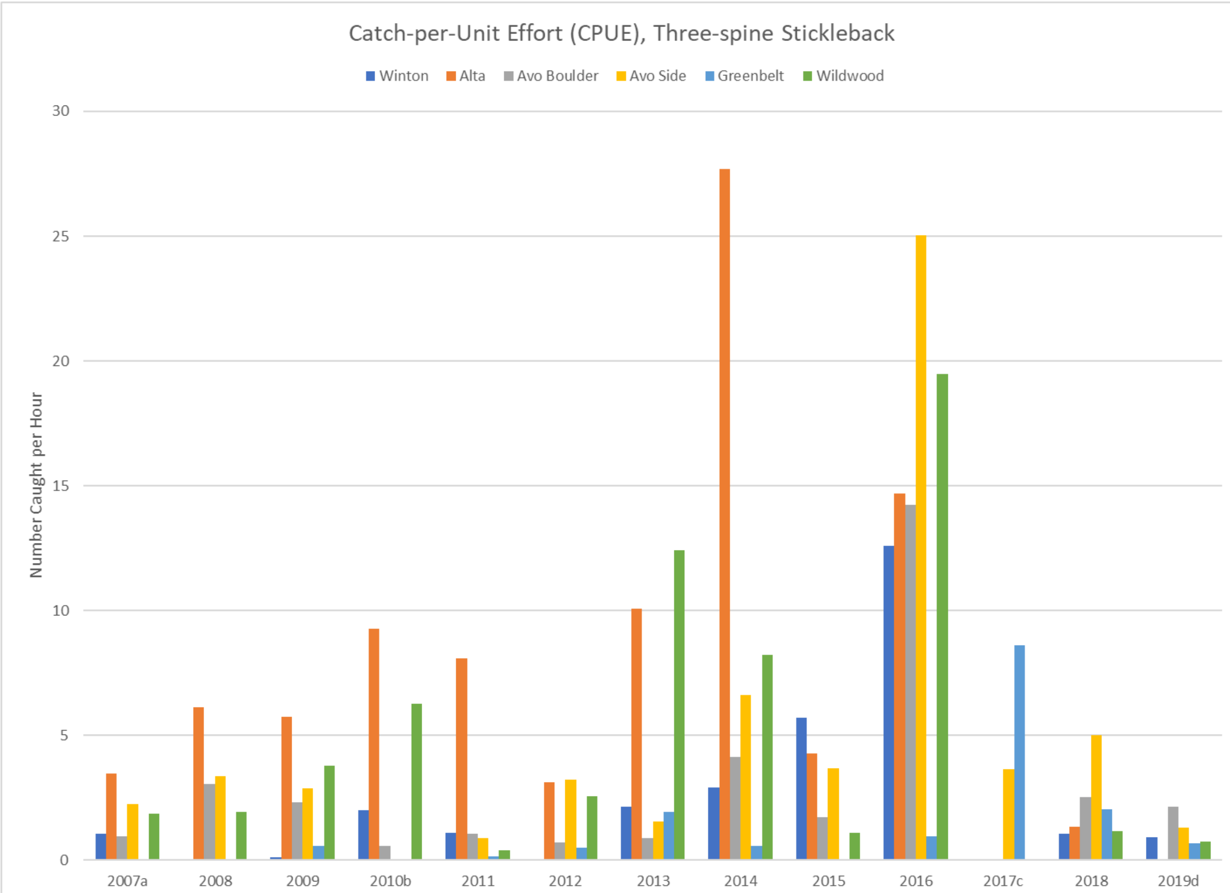

Figure 25. ***Catch-per-unit effort and number of three-spine stickleback captured per hour during the Fall Population Electro-fishing Survey, 2007-2019. Note that in 2007a nine sites were sampled, and in 2010b eight sites were sampled; data shown only represents that from the six core sites sampled annually. Due to unsafe survey conditions, two sites were sampled in 2017c, and five sites in 2019d.***

Population estimates for three-spine stickleback are summarized in Table 9 by site and year. The estimated population density per site varied among years, with detections occurring in all years but not at all sites. Three-spine stickleback were not detected at Greenbelt in 2007, Winton and Greenbelt in 2008, Avo Side and Greenbelt in 2010, Winton in 2012, and Greenbelt in 2015. The site with the greatest estimated population density was Avo Side with 3,727 fish*ha^{-1} 2016 (Figure 26). Due to extended low flows (Figure 1) in 2015 riverine conditions may have favored increased survival, with many sticklebacks able to survive and reproduce in 2016, producing a large cohort which was then captured in the fall. While habitat data is not available, the Alta site has been observed as being well suited for stickleback having extensive shallow habitat with slow-moving water and suitable spawning substrate present. In later years, the Avo Boulder site contained the bulk of the stickleback captured. It is unknown if this was due to changes in riverine habitat at the Avo Boulder site making it more suitable for stickleback or some other factors.

Table 9. ***Population estimates for three-spine stickleback, 2007-2019, with 95% CI, lower CI adjusted in parenthesis, as calculated by MicroFish 3.0.***

Population Estimate (95% CI, Lower CI Adjusted), Three-spine Stickleback						
Year	**Winton**	**Alta**	**Avo Boulder**	**Avo Side**	**Greenbelt**	**Wildwood**
2007[a]	12 (12-12)	46 (46-46)	7 (7-10	21 (16-37)	0 (0-0)	22 (13-58)
2008	0 (0-0)	36 (36-37)	27 (20-46)	25 (19-42)	0 (0-0)	101 (31-405)
2009	1 (1-1)	58 (58-58)	33 (21-67)	21 (17-33)	5 (5-7)	25 (23-31)
2010[b]	20 (17-29)	122 (59-250)	4 (4-9)	0 (0-0)	0 (0-0)	69 (69-69)
2011	40 (9-360)	50 (38-72)	9 (9-11)	4 (4-7)	1 (1-1)	3 (3-8)
2012	0 (0-0)	54 (54-54)	6 (6-10)	36 (36-36)	4 (4-4)	30 (30-30)
2013	15 (15-17)	64 (64-64)	6 (6-6)	10 (10-11)	28 (15-79)	150 (101-208)
2014	46 (46-46)	258 (230-286)	55 (31-115)	60 (58-64)	6 (6-6)	151 (63-349)
2015	75 (48-124)	31 (31-32)	21 (21-21)	20 (20-21)	0 (0-0)	40 (9-390)
2016	158 (92-249)	117 (78-170)	142 (142-142)	559 (129-1,750)	6 (6-10)	175 (118-237)
2017[c]	-	-	-	57 (152-192)	116 (82-159)	-
2018	20 (20-20)	10 (10-12)	24 (24-24)	107 (32-436)	28 (15-79)	12 (10-21)
2019[d]	9 (8-15)	-	13 (13-15)	14 (14-14)	5 (5-5)	6 (5-15)

a = nine sites sampled, but data shown represents only that from the six core sites sampled annually

b = eight sites sampled, but data shown represents only that from the six core sites sampled annually

c = only two sites sampled due to unsafe flows for surveying at other sites

d = only five sites sampled due to adverse weather at Alta creating unsafe survey conditions

Figure 26. ***Estimated population density of three-spine stickleback per site during the Fall Population Electro-fishing Survey, 2007-2019. Note that in 2007a nine sites were sampled, and in 2010b eight sites were sampled; data shown only represents that from the six core sites sampled annually. Due to unsafe survey conditions, two sites were sampled in 2017c, and five sites in 2019d.***

Fish per mile estimates were often greatest in the Alta and Wildwood sites from 2007 through 2016, with Avo Side having a large increase in 2016. Three-spine stickleback were absent in some years from Avo Side, Greenbelt, and Winton. The highest estimated number of fish was at Avo Side in 2016 at 9,838 fish per mile (Figure 27).

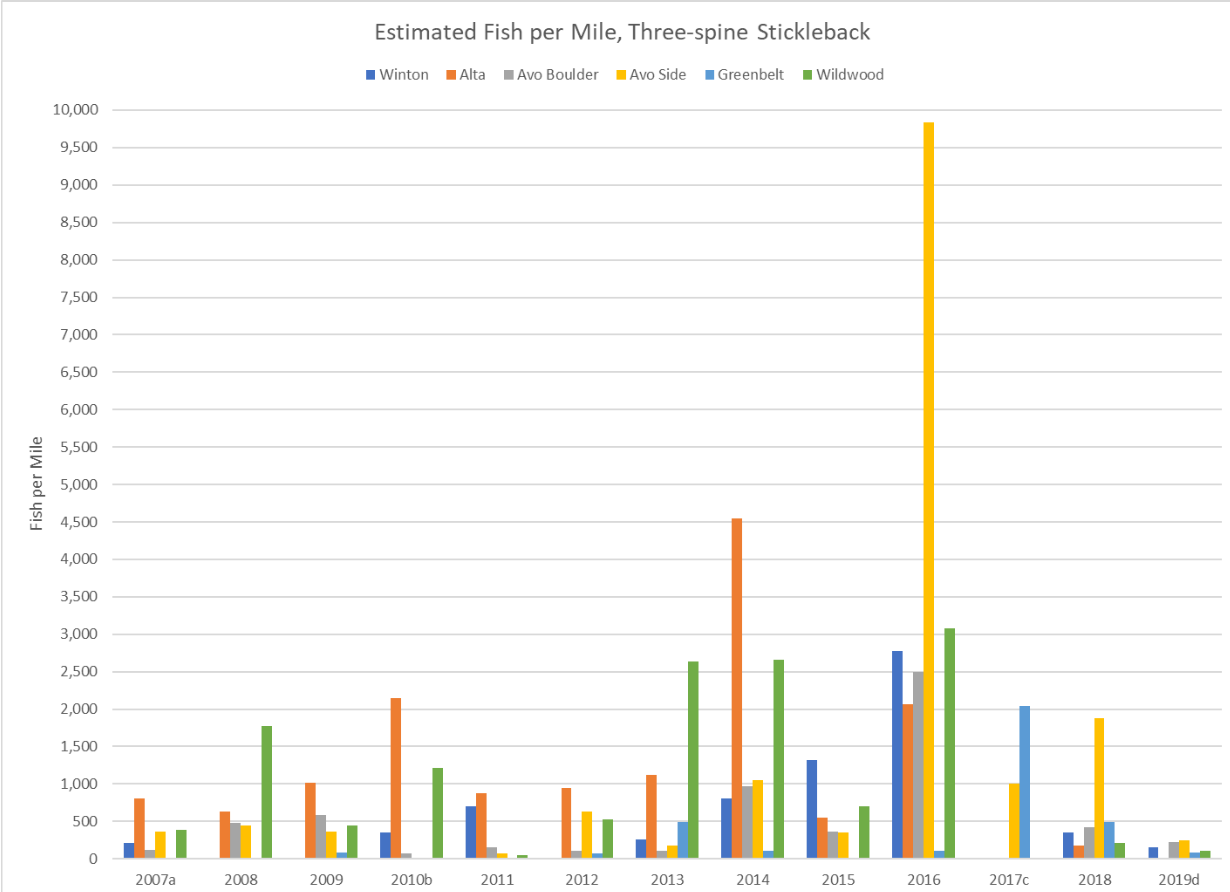

Figure 27. ***Estimated number of fish per mile for three-spine stickleback per site during the Fall Population Electro-fishing Survey, 2007-2019. Note that in 2007a nine sites were sampled, and in 2010b eight sites were sampled; data shown only represents that from the six core sites sampled annually. Due to unsafe survey conditions, two sites were sampled in 2017c, and five sites in 2019d.***

Biomass of captured three-spine stickleback was relatively steady across sites, with exceptions in 2014 and 2016 when increases in the population were observed. Three-spine stickleback were not captured at all sites in some years, the heaviest overall biomass collected was 0.4 lbs (166 g) from Avo Side in 2016 (Figure 28).

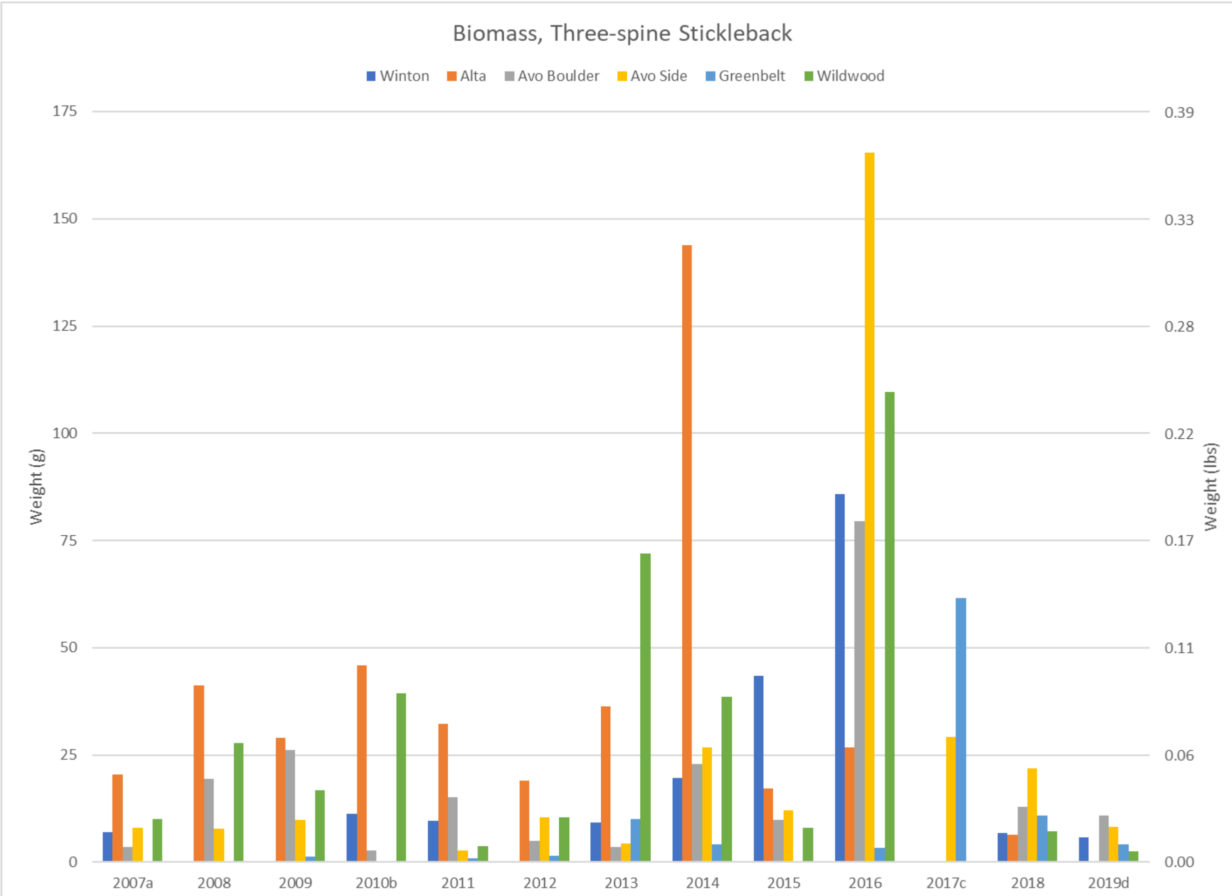

Figure 28. ***Biomass of captured stickleback per site for each Fall Population Electro-fishing Survey, 2007-2019. Note that in 2007a nine sites were sampled, and in 2010b eight sites were sampled; data shown only represents that from the six core sites sampled annually. Due to unsafe survey conditions, two sites were sampled in 2017c, and five sites in 2019d.***

Captured three-spine stickleback were frequently small, although length ranged from 1 to 6 inches (Figure 29), with 99% of captured fish smaller than 2 inches, which is the typical size for freshwater sticklebacks. Sticklebacks rarely live longer than 1 year and shoal with similar sized cohorts. Some sticklebacks have been known to live for two or three years, and obtain larger sizes, but they are an exception (Moyle 2002).

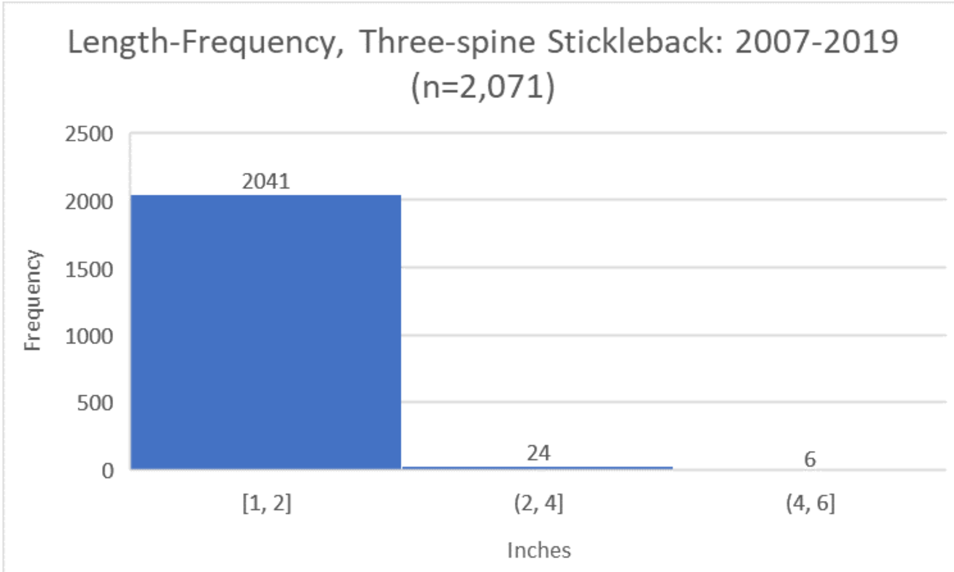

Figure 29. ***Length-frequency of three-spine stickleback captured during the Fall Population Electro-fishing Surveys, 2007-2019. The number of fish in each size class is shown.***

Ictaluridae – Catfish and Bullhead Family

A total of 39 ictalurids, represented in the Kings River by brown bullhead and white catfish were captured between 2007 and 2019. Identification between species of this family was not made for most years of data collection. Catch-per-unit effort ranged from 0 to 2.10 fish per hour and is provided in Appendix C. Captures of catfish have been inconsistent over the sampling period; although they are most regularly captured in the Greenbelt site where reduced flows over Fresno Weir and the warmer temperatures downstream may make for increased habitat suitability for catfish.

Population estimates for catfish ranged from 0 (95% CI, lower CI adjusted, 0-0) to 15 (95% CI, lower CI adjusted, 15-17) fish per siteTable 1. The estimated population density per site varied among years. In some years, no catfish were detected. In years catfish were detected, they were not present in all sites. The site with the greatest estimated population density was Greenbelt with 56 fish*ha^{-1} in 2014. Extended reduced flows, particularly over Fresno Weir, and the warmer water throughout the river may have provided favorable conditions for catfish. Temperatures over 70˚F (21˚C) are preferred for spawning, and habitats with slow currents are preferred (Moyle 2002).

Fish per mile estimates were variable from year to year. No catfish were detected in some years, while the highest estimated number was 264 fish per mile in 2014 at Greenbelt.

Biomass of captured catfish was variable. They were collected in all sites except Alta but were not collected in all years. The heaviest overall biomass collected was 0.9 lbs (395 g) from Greenbelt in 2018.

Captured catfish were frequently small, although length ranged from 2 to 13 inches, with 92% of captured fish smaller than 4 inches. Catfish mature at 7 inches (200 mm) (Moyle 2002), indicating most of the catfish captured were juveniles. The presence of juvenile catfish indicates that catfish can successfully spawn in the Kings River when conditions are favorable.

Petromyzontidae – Lamprey Family

A total of 2,648 petromyzontids, represented in the Kings River by the Kern brook lamprey and possibly other lamprey species, were captured between 2007 and 2019 (Appendix B). Species identification was not made for most years of data collection. Catch-per-unit effort is shown in Figure 30 and provided in Appendix C. While catch-per-unit effort varied by site it remained relatively consistent over time, suggesting the lamprey population was relatively stable in the Kings River over the survey period.

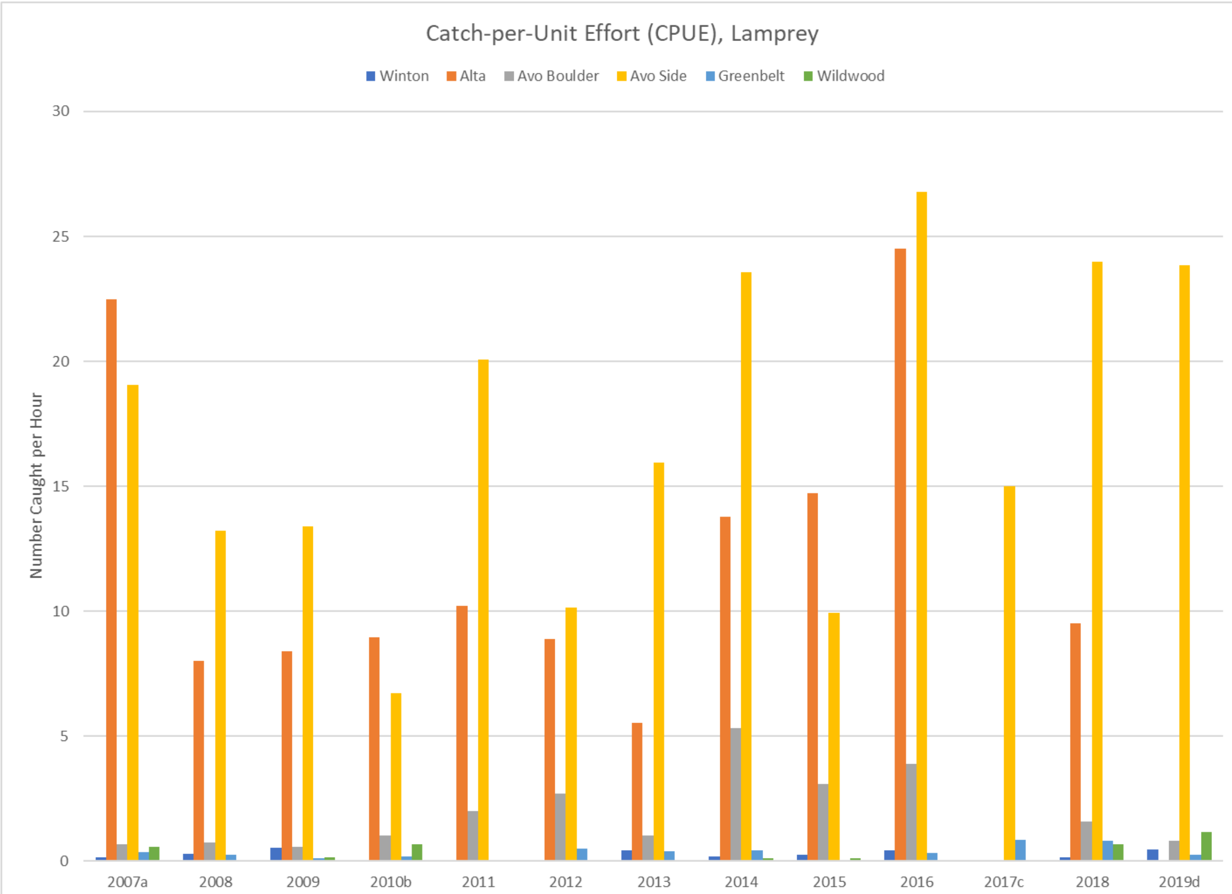

Figure 30. ***Catch-per-unit effort and number of lamprey captured per hour during the Fall Population Electro-fishing Survey, 2007-2019. Note that in 2007a nine sites were sampled, and in 2010b eight sites were sampled; data shown only represents that from the six core sites sampled annually. Due to unsafe survey conditions, two sites were sampled in 2017c, and five sites in 2019d.***

Population estimates for lamprey are summarized in Table 10 by site and year. The estimated population density per site varied among years, with detections occurring in all years but not at all sites (Figure 31). The site with the greatest estimated population density was Avo Side with 2,573 fish*ha^{-1} in 2016. Population density at Avo Side and Alta are consistently higher than others suggesting habitat in these sites may be more suitable for lamprey. While habitat data is not available, these two sites are within side channels which may provide habitat more suitable for spawning adults and the rearing of lamprey ammocetes. Ammocetes prefer reduced flows and areas with greater deposition of sand and mud, while adults require riffles with spawning gravel and rubble for cover (Moyle 2002).

Table 10. ***Population estimates for lamprey, 2007-2019, with 95% CI, lower CI adjusted in parenthesis, as calculated by MicroFish 3.0.***

Population Estimate (95% CI, Lower CI Adjusted), Lamprey						
Year	**Winton**	**Alta**	**Avo Boulder**	**Avo Side**	**Greenbelt**	**Wildwood**
2007[a]	1 (1-1)	407 (202-624)	5 (5-6)	204 (204-204)	3 (3-6)	8 (4-50)
2008	2 (2-2)	70 (70-70)	6 (5-15)	112 (112-112)	2 (2-7)	0 (0-0)
2009	4 (4-5)	86 (86-86)	5 (5-8)	118 (118-118)	1 (1-1)	1 (1-1)
2010[b]	0 (0-0)	141 (57-346)	7 (7-10)	42 (42-42)	1 (1-1)	13 (5-95)
2011	0 (0-0)	49 (48-52)	27 (17-60)	135 (135-135)	0 (0-0)	0 (0-0)
2012	0 (0-0)	154 (154-154)	24 (23-28)	114 (114-114)	4 (4-4)	0 (0-0)
2013	3 (3-4)	35 (35-35)	7 (7-8)	104 (102-108)	5 (3-32)	0 (0-0)
2014	3 (3-3)	164 (164-164)	43 (40-50)	210 (207-215)	5 (3-32)	1 (1-1)
2015	2 (2-15)	160 (160-160)	38 (38-38)	54 (54-54)	0 (0-0)	1 (1-1)
2016	3 (3-6)	165 (132-198)	35 (26-56)	386 (138-819)	2 (2-7)	0 (0-0)
2017[c]	-	-	-	362 (119-858)	10 (8-21)	-
2018	2 (2-2)	81 (71-94)	10 (10-11)	181 (157-205)	6 (6-10)	9 (9-9)
2019[d]	6 (6-6)	-	8 (8-8)	228 (174-282)	2 (2-15)	12 (12-12)

a = nine sites sampled, but data shown represents only that from the six core sites sampled annually

b = eight sites sampled, but data shown represents only that from the six core sites sampled annually

c = only two sites sampled due to unsafe flows for surveying at other sites

d = only five sites sampled due to adverse weather at Alta creating unsafe survey conditions

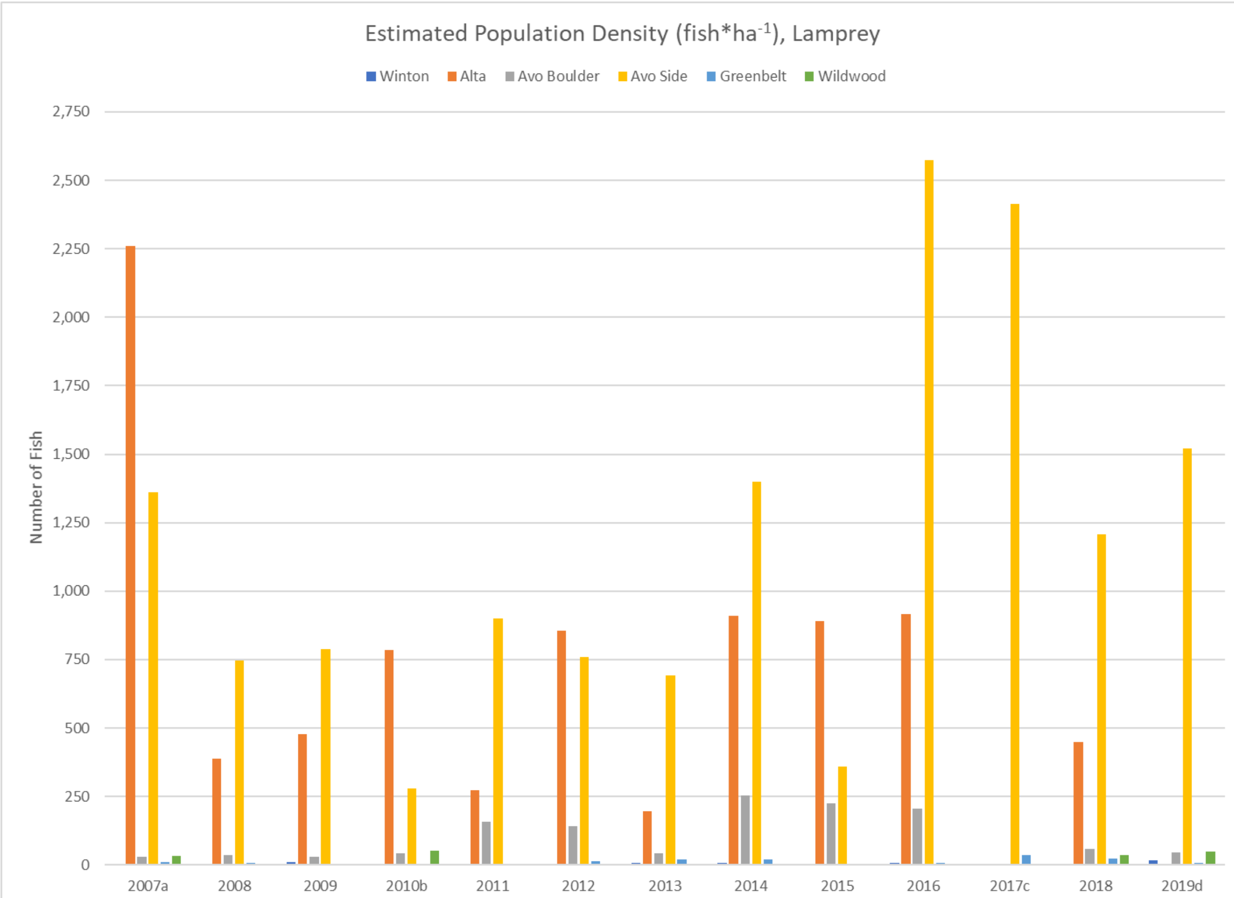

Figure 31. ***Estimated population density of lampreys per site during the Fall Population Electrofishing Survey, 2007-2019. Note that in 2007a nine sites were sampled, and in 2010b eight sites were sampled; data shown only represents that from the six core sites sampled annually. Due to unsafe survey conditions, two sites were sampled in 2017c, and five sites in 2019d.***

Fish per mile estimates were variable between sites and years, with lamprey absent in Greenbelt, Winton, and Wildwood in some years. Fish per mile estimates were typically highest in the sites Alta and Avo Side. The highest estimated number of lamprey was in Alta in 2007 at 7,163 fish per mile (Figure 32).

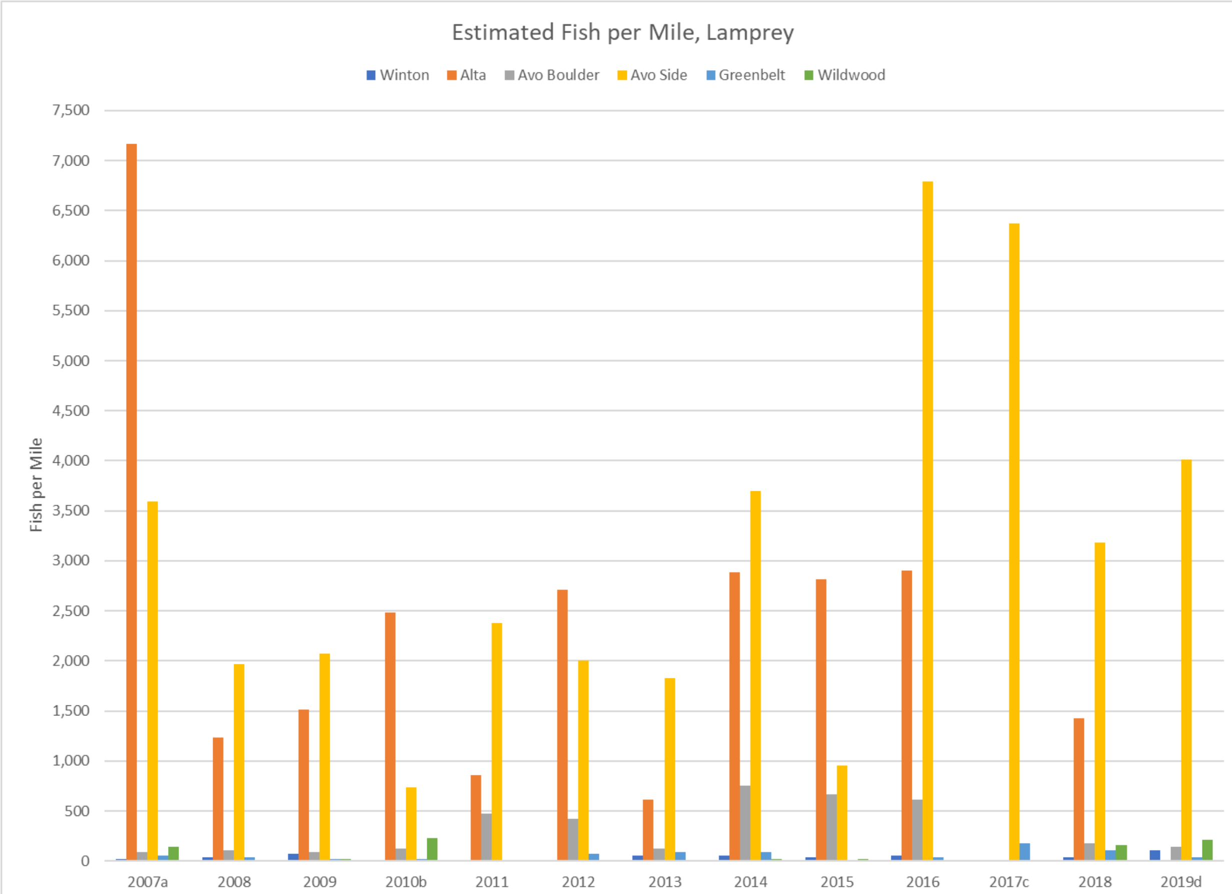

Figure 32. ***Estimated number of fish per mile for lamprey per site during the Fall Population Electro-fishing Survey, 2007-2019. Note that in 2007a nine sites were sampled, and in 2010b eight sites were sampled; data shown only represents that from the six core sites sampled annually. Due to unsafe survey conditions, two sites were sampled in 2017c, and five sites in 2019d.***

Biomass of captured lamprey was highly variable across sites, although consistently highest in Avo Side and Alta. Lamprey were captured in all sites, but not in all years, the heaviest biomass collected was 1.8 lbs (799 g) from Alta in 2007 (Figure 33). Sites with higher population estimates (Table 10) yielded higher biomass as would be expected.

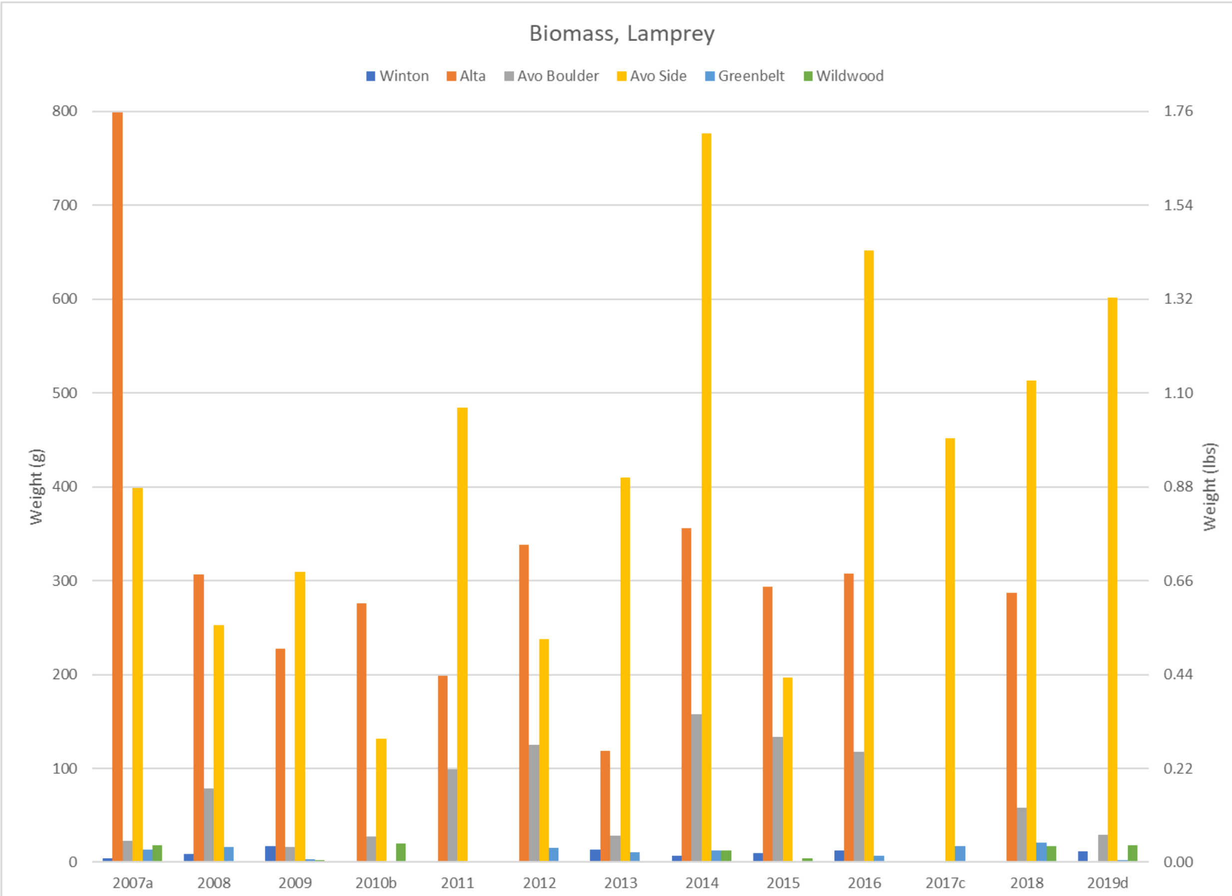

Figure 33. ***Biomass of captured lamprey per site for each Fall Population Electro-fishing Survey, 2007-2019. Note that in 2007a nine sites were sampled, and in 2010b eight sites were sampled; data shown only represents that from the six core sites sampled annually. Due to unsafe survey conditions, two sites were sampled in 2017c, and five sites in 2019d.***

Captured lamprey were frequently of moderate size, with length ranging from 2 to 7 inches (Figure 34), with 68% of captured fish 5 to 6 inches. Non-parasitic adult lamprey, such as found in the Kings River, are generally smaller following metamorphoses from the ammocetes stage (McGinnis 2006). It is unknown how many lamprey may have been adults as data collected on these surveys did not distinguish between ammocetes and adults.

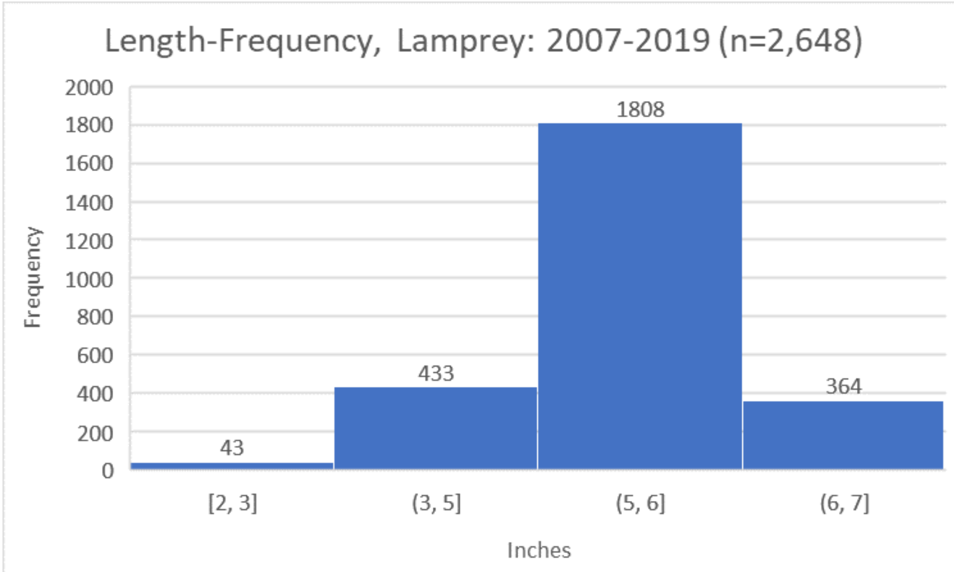

Figure 34. ***Length-frequency of lamprey captured during the Fall Population Electro-fishing Surveys, 2007-2019. The number of fish in each size class is shown.***

Poecillidae – Livebearer Family

A total of 121 poecillids, represented by the western mosquitofish were captured between 2007 and 2019 (Appendix B). Catch-per-unit effort ranged from 0 to 3.17 fish per hour and is provided in Appendix C. Western mosquitofish were generally not captured outside of the 2012-2016 drought years, except for 2008, which concluded a prior drought cycle.

Population estimates for western mosquitofish ranged from 0 (95% CI, lower CI adjusted, 0-0) to 23 (95% CI, lower CI adjusted, 23-24) fish per siteTable 1. The estimated population density per site varied among years. In some years, no fish were detected, while the site with the greatest estimated population density was Alta with 128 fish*ha^{-1} in 2015. The population increase seen during the extended 2012-2016 drought cycle may have been due to increase in population either due to intentional introductions of western mosquitofish into the river or tributary streams, or increased reproduction of a population which during most years was too suppressed to be detectable on population surveys. Due to the low numbers of western mosquitofish detected, conditions in the area surveyed below Pine Flat Dam may not be ideal for survival. While they can handle streams and prefer shallow water with temperatures up to 108˚F (42˚C), they do not do well when piscivorous fish are present (Moyle 2002). The only site which they were never detected was Avo Boulder, which may not be suitable for western mosquitofish due to habitat factors, interspecies competition, or predation by piscivorous fish. Sites Alta, Greenbelt, and Wildwood resulted in western mosquitofish captures with the greatest frequency, suggesting conditions in these sites were more suitable for them. Alta supported a population in five out of thirteen years and, Greenbelt and Wildwood supported a population in three out of thirteen years.

Fish per mile estimates were variable from year to year, with no western mosquitofish detected in some years and the highest estimated number at 405 fish per mile in Alta in 2015.

Biomass of captured western mosquitofish was variable. The heaviest collected biomass was 0.02 lbs (7 g) from Wildwood in 2015.

Captured western mosquitofish were frequently of typical size, with lengths ranging from 1 to 2 inches, with 71% of captured fish 1 inch in length. All captured fish would have been adults as males reach maturity at 0.75 inches (19 mm) and females are usually 1 inch (24 mm) at first pregnancy (Moyle 2002).

Salmonidae – Trout and Salmon Family

A total of 323 salmonids, represented by 9 brook trout, 142 hatchery rainbow trout, and 172 "wild" rainbow trout were captured between 2007 and 2019 (Appendix B). Catch-per-unit effort for brook trout, captured only in 2010 ranged from 0 to 1.1. Catch-per-unit effort for hatchery rainbow trout and "wild" rainbow trout are shown in Figure 35 and Figure 36. Annual catch-per-unit effort for brook trout, hatchery rainbow trout, and "wild" rainbow trout is provided in Appendix C. Catch-per-unit effort of brook trout and hatchery rainbow trout may be influenced by proximity to stocking location as well as the time between a hatchery stocking event and electro-fishing survey. Catch-per-unit effort of hatchery fish remained steady over much of the survey period, with increases seen in 2007 and 2019 suggesting stocking activity may have influenced the capture rates. In 2007 captures were largely driven at Alta, which sits 0.1 miles upstream of a stocking location, providing stocked fish a short upstream dispersal into the sampling site. The 2019 catch-per-unit effort was largely driven by site Avo Boulder. Stocking occurs both 0.15 and 0.5 miles upstream of this site, and the increase seen here, may have been due to increased stocking through the supplemental stocking program. Catch-per-unit effort of "wild" rainbow trout varied over time, with decreases seen during the 2012-2016 drought when instream conditions may not have been favorable for "wild" rainbow trout. Hatchery rainbow trout were not captured below Fresno Weir, excepting one trout captured at Greenbelt in 2017. The nearest stocking locations to this site are approximately 3 miles upstream or 2 miles downstream.

Brook trout are not stocked in all years. When stocked by CDFW they have typically reached the end of their usage as biological cleaners or broodstock at the San Joaquin Hatchery and are stocked most often as catchables, super-catchables, and trophy trout. Hatchery rainbow trout are stocked as fingerlings, sub-catchables, catchables, super-catchables, and trophy trout, although not all size classes are stocked in all years (Appendix D: Table D1). Stocking by CDFW typically occurs on a weekly or bi-monthly basis so long as water temperatures remain less than 70˚F (21˚C). Supplemental stocking, which began in October 2018 occurs on a weekly basis October through March. Stocking locations range from 0.1 to 0.7 miles away from the four sample sites located above Fresno Weir. Below Fresno Weir the river is occasionally stocked; with the closest stocking location to an electro-fishing site being at Highway 180, 0.6 miles downstream of the southernmost sample site. Catch-per-unit effort may also be influenced by misclassification of hatchery rainbow trout and "wild" rainbow trout. While fin condition, color, the presence/absence of an adipose fin have all been used to distinguish these classes, hatchery rainbow trout which have become resident may take on coloration like "wild" rainbow trout and worn fins will regenerate over time, possibly leading to misclassification. Additionally, no phenotypic distinction can be made between trout hatched in the incubator and those which were spawned instream. Due to the young age at release, five to seven weeks post-hatch, incubator-hatched trout rear under the same conditions as stream spawned trout, making fin condition and color an unreliable indicator of origin, thus increasing the potential for misclassification of these hatchery rainbow trout as "wild" rainbow trout.

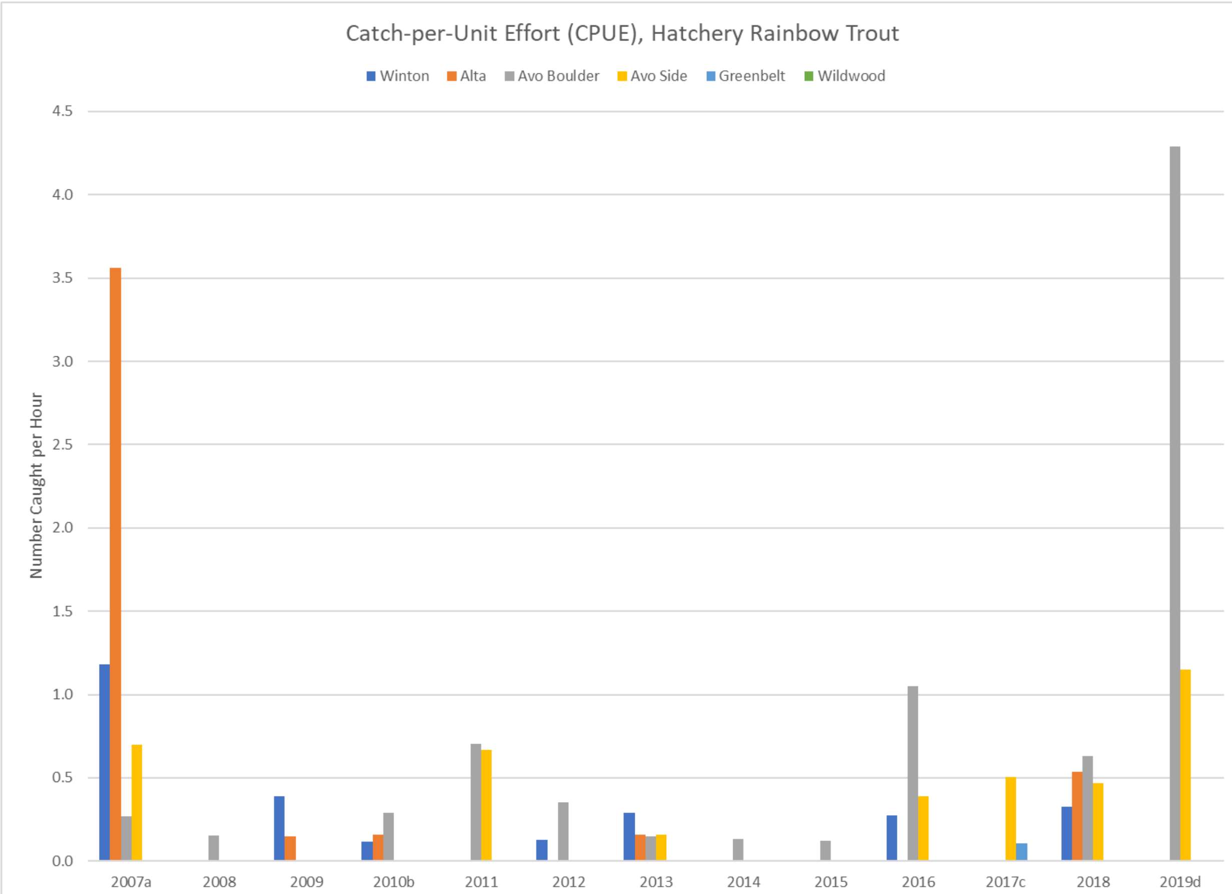

Figure 35. ***Catch-per-unit effort and number of hatchery rainbow trout captured per hour during the Fall Population Electro-fishing Survey, 2007-2019. Note that in 2007a nine sites were sampled, and in 2010b eight sites were sampled; data shown only represents that from the six core sites sampled annually. Due to unsafe survey conditions, two sites were sampled in 2017c, and five sites in 2019d.***

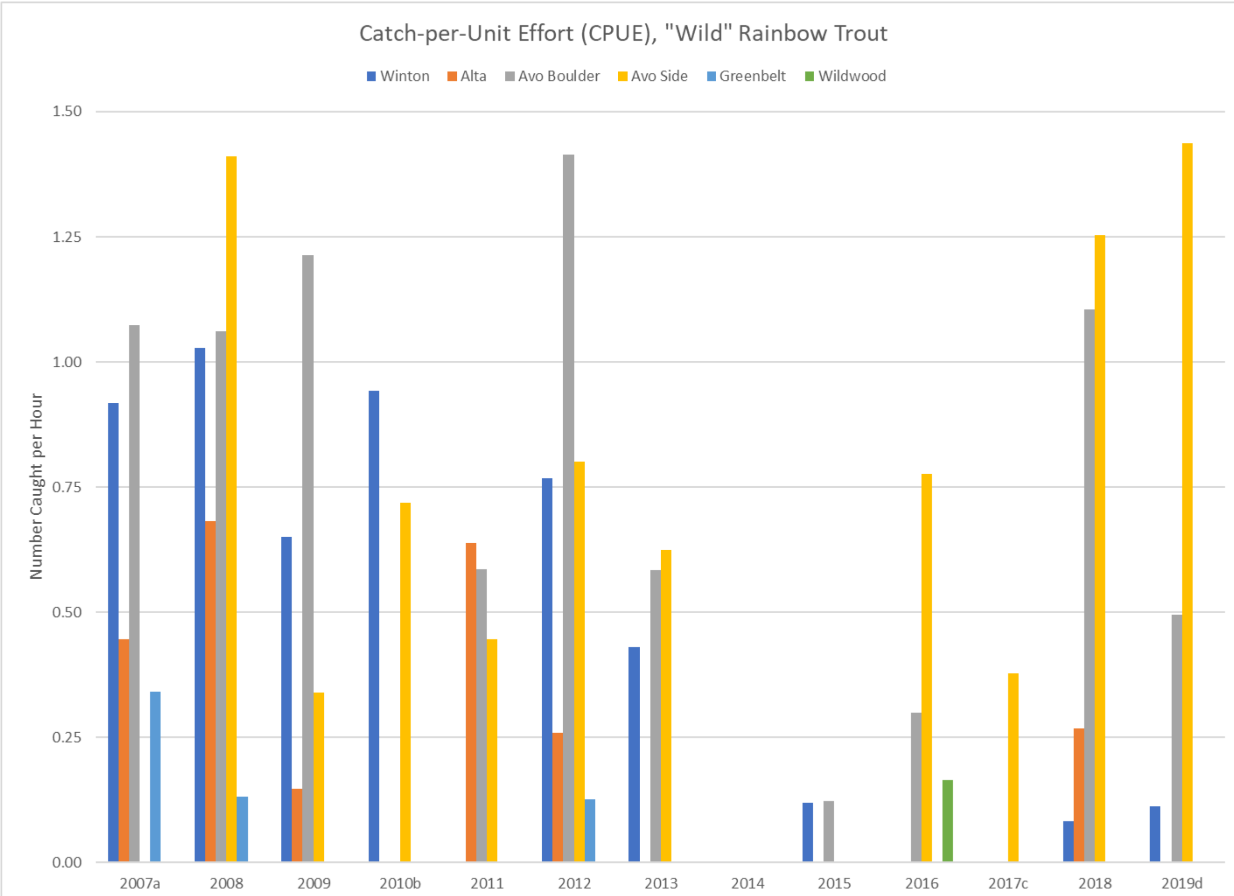

Figure 36. ***Catch-per-unit and number of "wild" rainbow trout captured per hour during the Fall Population Electro-fishing Survey, 2007-2019. Note that in 2007a nine sites were sampled, and in 2010b eight sites were sampled; data shown only represents that from the six core sites sampled annually. Due to unsafe survey conditions, two sites were sampled in 2017c, and five sites in 2019d.***

The population estimate for brook trout in 2010 was 7 (95% CI, lower CI adjusted, (7-7) fish. Population estimates for hatchery rainbow trout and "wild" rainbow trout are summarized in Table 11 and Table 12 by site and year. The estimated population density of salmonids varied among years. Brook trout were captured only in 2010, with the greatest estimated population density in Alta at 39 fish*ha^{-1}. Brook trout are not resident in the Kings River; being present only following stocking by CDFW. Hatchery rainbow trout were detected in all years, but not at all sites. The site with the greatest estimated population density was Avo Boulder, with 241 fish*ha^{-1} in 2019 (Figure 37). "Wild" rainbow trout were detected in all years except 2014, and the site with the greatest estimated population density was Avo Boulder in 2012 with 71 fish*ha^{-1} (Figure 38).

Hatchery rainbow trout are most commonly present in those sites near regularly stocked locations above Fresno Weir. Hatchery rainbow trout have been found in only one site below Fresno Weir in thirteen years of sampling. Reaches below Fresno Weir are not managed as part of the trout fishery as temperatures in the late summer and fall may reach levels unsuitable to trout over a long-term exposure. As such, stocking below Fresno Weir occurs with less regularity than between Fresno Weir and the Pine Flat Dam. Population estimates for hatchery rainbow trout may be lower than expected considering frequency of stocking events. Low population estimates suggest: 1) poor dispersal from stocking locations, 2) angler pressure is high, 3) high predation by piscivorous fish & wildlife, 4) survival of hatchery trout upon release is poor, or 5) some combination of these factors. Population estimates for "wild" rainbow trout may be overestimated due to the impossibility of separating incubator-hatched trout from that produced instream. While some instream production may occur, much of the substrate is unsuitable for successful spawning due to large size and armoring (Cramer Fish Sciences 2019).

Declines in the "wild" trout population were seen during the 2012-2016 drought, followed by apparent recovery in recent years. This suggests during the drought instream conditions became unsuitable for trout. In 2014 no "wild" trout were found, a year daily average release temperatures from the dam were greater than 68˚F (20˚C) for almost a three-month period (Figure 2) in the late summer and early fall due to extreme climatic conditions. Temperatures, up to three degrees warmer were occurring downstream during this same time (Figure 3). Optimal temperatures for rainbow trout are 59 to 64˚F (15 to 18˚C) (Moyle 2002). Feeding is reduced at temperatures greater than 68˚F (20˚C) (Woynarovich et al. 2011) and temperatures may become lethal in the range of 75 to 81˚F (24 to 27˚C) unless the exposure is brief (Moyle 2002). Although no "wild" rainbow trout were captured in 2014 this should not be interpreted to indicate they were fully excluded from the river below Pine Flat Dam. Suitable refugia may be present which can provide protection for a limited number of "wild" rainbow trout from thermal stressors, and these fish may have remained undetected during sampling either due to low population or a lack of suitable refugia in or near sample sites. "Wild" rainbow trout were found in subsequent years, supporting the theory that they were not extirpated from the tailwater fishery in 2014.

Table 11. ***Population estimates for hatchery rainbow trout, 2007-2019, with 95% CI, lower CI adjusted in parenthesis, as calculated by MicroFish 3.0.***

Population Estimate (95% CI, Lower CI Adjusted), Hatchery Rainbow Trout						
Year	**Winton**	**Alta**	**Avo Boulder**	**Avo Side**	**Greenbelt**	**Wildwood**
2007[a]	9 (9-10)	40 (32-56)	2 (2-15)	8 (8-8)	0 (0-0)	0 (0-0)
2008	0 (0-0)	0 (0-0)	1 (1-1)	0 (0-0)	0 (0-0)	0 (0-0)
2009	3 (3-3)	1 (1-1)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)
2010[b]	1 (1-1)	1 (1-1)	2 (2-2)	0 (0-0)	0 (0-0)	0 (0-0)
2011	0 (0-0)	0 (0-0)	6 (6-7)	3 (3-6)	0 (0-0)	0 (0-0)
2012	1 (1-1)	0 (0-0)	3 (3-4)	0 (0-0)	0 (0-0)	0 (0-0)
2013	2 (2-7)	1 (1-1)	1 (1-1)	1 (1-1)	0 (0-0)	0 (0-0)
2014	0 (0-0)	0 (0-0)	1 (1-1)	0 (0-0)	0 (0-0)	0 (0-0)
2015	0 (0-0)	0 (0-0)	1 (1-1)	0 (0-0)	0 (0-0)	0 (0-0)
2016	2 (2-2)	0 (0-0)	7 (7-8)	2 (2-2)	0 (0-0)	0 (0-0)
2017[c]	-	-	-	4 (4-6)	1 (1-1)	-
2018	4 (4-4)	4 (4-4)	4 (4-6)	3 (3-4)	0 (0-0)	0 (0-0)
2019[d]	0 (0-0)	-	41 (26-79)	13 (8-40)	0 (0-0)	0 (0-0)

a = nine sites sampled, but data shown represents only that from the six core sites sampled annually

b = eight sites sampled, but data shown represents only that from the six core sites sampled annually

c = only two sites sampled due to unsafe flows for surveying at other sites

d = only five sites sampled due to adverse weather at Alta creating unsafe survey conditions

Table 12. ***Population estimates for "wild" rainbow trout, 2007-2019, with 95% CI, lower CI adjusted in parenthesis, as calculated by MicroFish 3.0.***

Population Estimate (95% CI, Lower CI Adjusted), "Wild" Rainbow Trout						
Year	**Winton**	**Alta**	**Avo Boulder**	**Avo Side**	**Greenbelt**	**Wildwood**
2007[a]	24 (7-200)	4 (4-5)	8 (8-10)	0 (0-0)	3 (3-8)	0 (0-0)
2008	7 (7-10)	4 (4-7)	7 (7-9)	8 (8-10)	1 (1-1)	0 (0-0)
2009	5 (5-6)	1 (1-1)	11 (11-13)	2 (2-26)	0 (0-0)	0 (0-0)
2010[b]	8 (8-10)	0 (0-0)	0 (0-0)	3 (3-8)	0 (0-0)	0 (0-0)
2011	0 (0-0)	3 (3-8)	5 (5-8)	2 (2-7)	0 (0-0)	0 (0-0)
2012	18 (6-140)	3 (3-8)	12 (12-14)	9 (9-9)	1 (1-1)	0 (0-0)
2013	3 (3-8)	0 (0-0)	4 (4-6)	4 (4-6)	0 (0-0)	0 (0-0)
2014	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)
2015	1 (1-1)	0 (0-0)	1 (1-1)	0 (0-0)	0 (0-0)	0 (0-0)
2016	0 (0-0)	0 (0-0)	2 (2-2)	4 (4-6)	0 (0-0)	1 (1-1)
2017[c]	-	-	-	3 (3-8)	0 (0-0)	-
2018	1 (1-1)	2 (2-2)	7 (7-10)	8 (8-9)	0 (0-0)	0 (0-0)
2019[d]	1 (1-1)	-	3 (3-8)	10 (10-11)	0 (0-0)	0 (0-0)

a = nine sites sampled, but data shown represents only that from the six core sites sampled annually

b = eight sites sampled, but data shown represents only that from the six core sites sampled annually

c = only two sites sampled due to unsafe flows for surveying at other sites

d = only five sites sampled due to adverse weather at Alta creating unsafe survey conditions

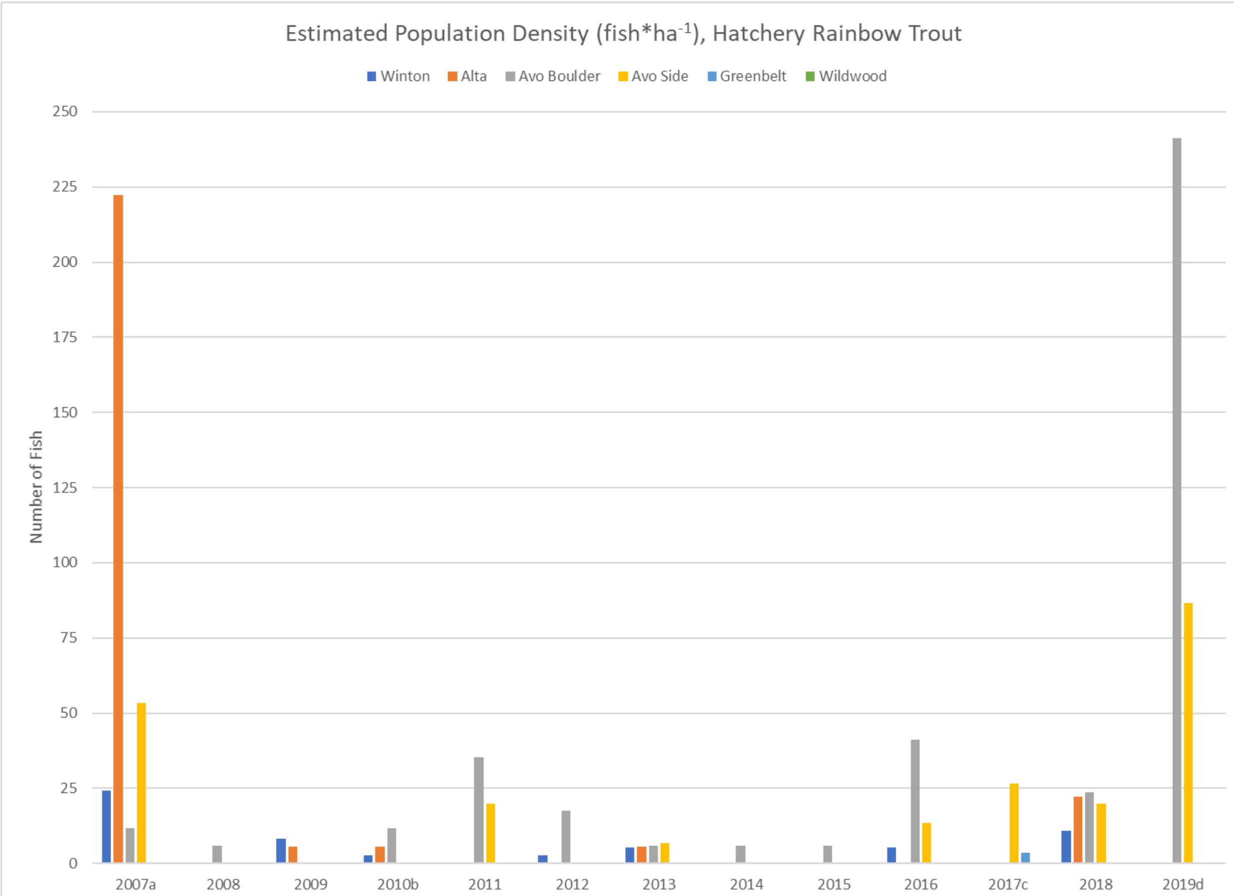

Figure 37. ***Estimated population density of hatchery rainbow trout per site during the Fall Population Electro-fishing Survey, 2007-2019. Note that in 2007a nine sites were sampled, and in 2010b eight sites were sampled; data shown only represents that from the six core sites sampled annually. Due to unsafe survey conditions, two sites were sampled in 2017c, and five sites in 2019d.***

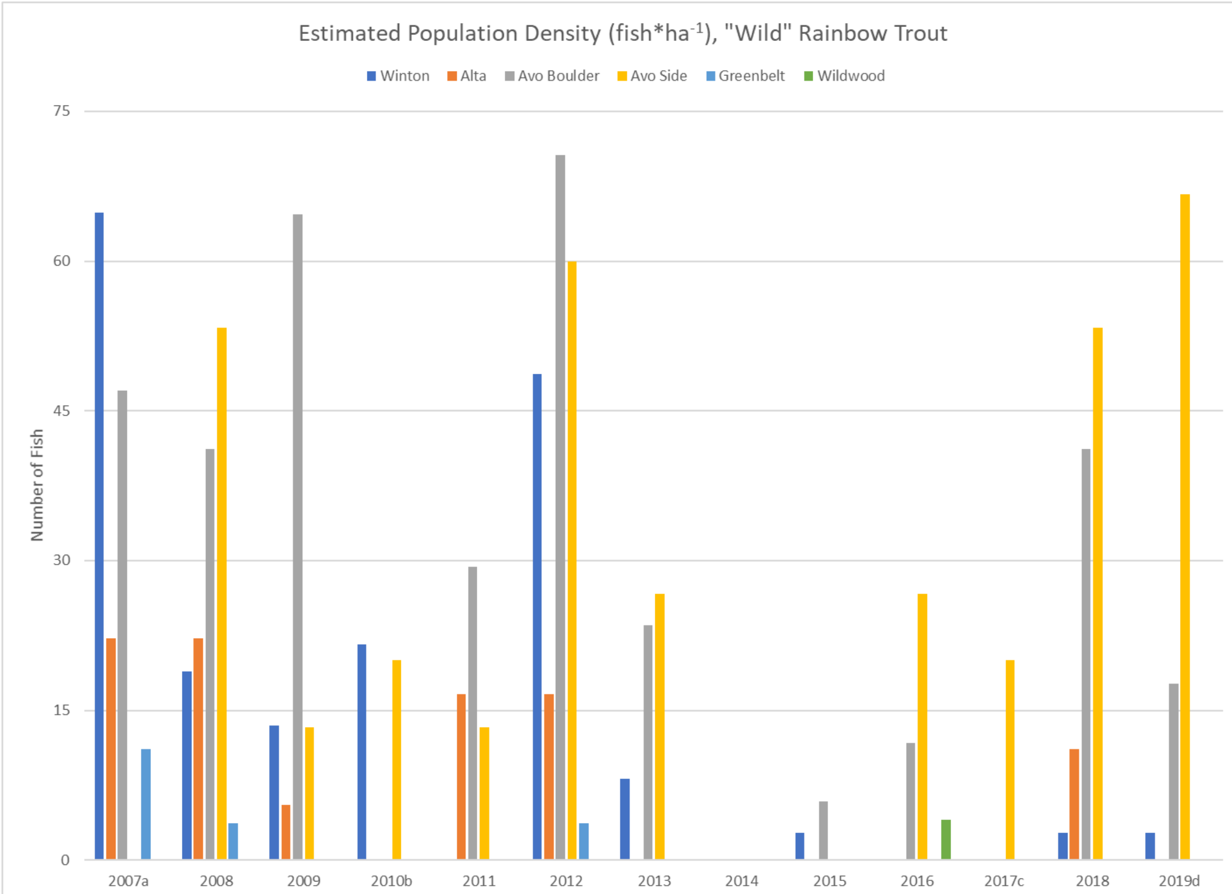

Figure 38. ***Estimated population density of "wild" rainbow trout per site during the Fall Population Electro-fishing Survey, 2007-2019. Note that in 2007a nine sites were sampled, and in 2010b eight sites were sampled; data shown only represents that from the six core sites sampled annually. Due to unsafe survey conditions, two sites were sampled in 2017c, and five sites in 2019d.***

Fish per mile was variable from year to year. Brook trout were detected only in 2010, when they were estimated at 123 fish per mile in Alta. Hatchery rainbow trout were detected in all years but not at all sites, and never in Wildwood. The highest estimated number of hatchery rainbow trout was at Avo Boulder in 2019 at 722 fish per mile (Figure 39). "Wild" rainbow trout were detected in all years except 2014 and have not been detected in all sites in all years. The highest estimated number of "wild" rainbow trout was at Winton in 2007 at 422 fish per mile (Figure 40).

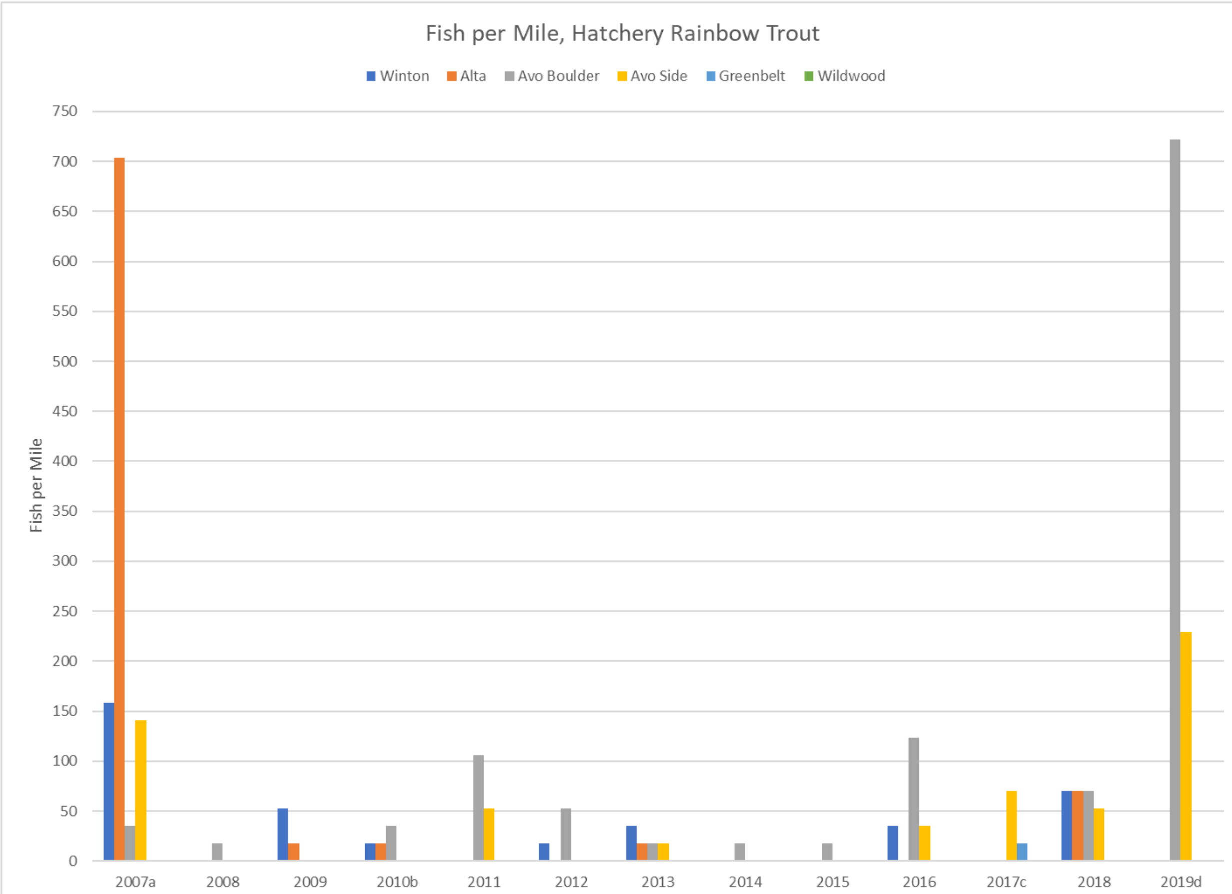

Figure 39. ***Estimated number of fish per mile for hatchery rainbow trout per site during the Fall Population Electro-fishing Survey, 2007-2019. Note that in 2007a nine sites were sampled, and in 2010b eight sites were sampled; data shown only represents that from the six core sites sampled annually. Due to unsafe survey conditions, two sites were sampled in 2017c, and five sites in 2019d.***

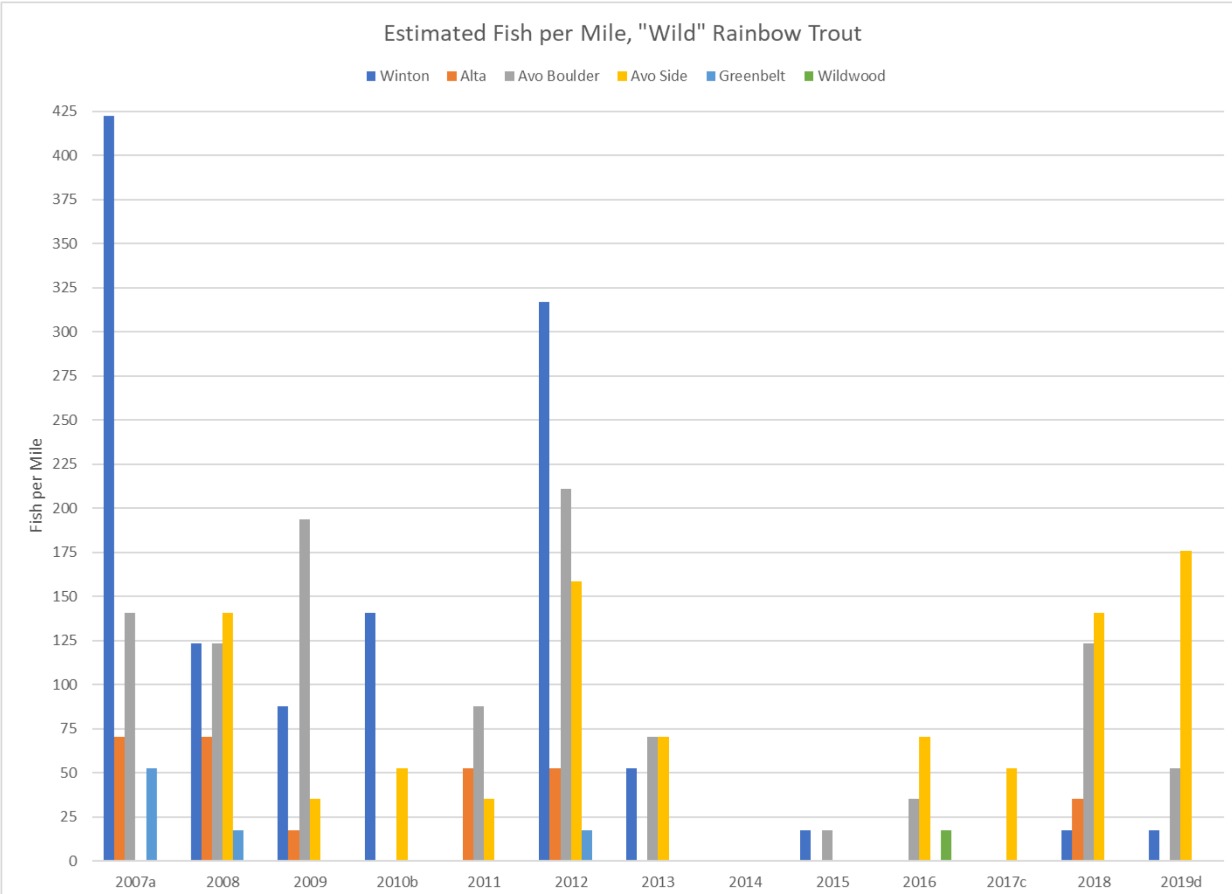

Figure 40. ***Estimated number of fish per mile for "wild" rainbow trout per site during the Fall Population Electro-fishing Survey, 2007-2019. Note that in 2007a nine sites were sampled, and in 2010b eight sites were sampled; data shown only represents that from the six core sites sampled annually. Due to unsafe survey conditions, two sites were sampled in 2017c, and five sites in 2019d.***

Biomass of captured salmonids was highly variable. Of the brook trout, the heaviest biomass collected was 16.3 lbs (7,427 g) at Alta in 2010. Hatchery rainbow trout were collected in all years but not at all sites, with the heaviest biomass collected of 9.0 lbs (4,095 g) from Avo Boulder in 2019 (Figure 41). "Wild" rainbow trout were collected in all years except 2014, with the heaviest biomass collected of 5.8 lbs (2,627 g) from Avo Boulder in 2011 (Figure 42).

Biomass of hatchery rainbow trout will be influenced most by the size of fish being stocked, amount of time they have been in river, ability to adapt to riverine conditions. "Wild" rainbow trout were regularly captured in site Avo Boulder. This site may provide more holding areas for larger trout, and increases were seen following high instream flows in 2011 and

2019 (Figure 1) due in part to necessary flood control releases into the tailrace. High instream flows in 2017 may have yielded similar results, but the site was not sampled due to unsafe wading conditions on account of high-water levels. These higher instream flows may have provided better instream conditions for trout and releases over the top of the dam may have also increased the potential for trout as well as other reservoir species to be recruited into the river.

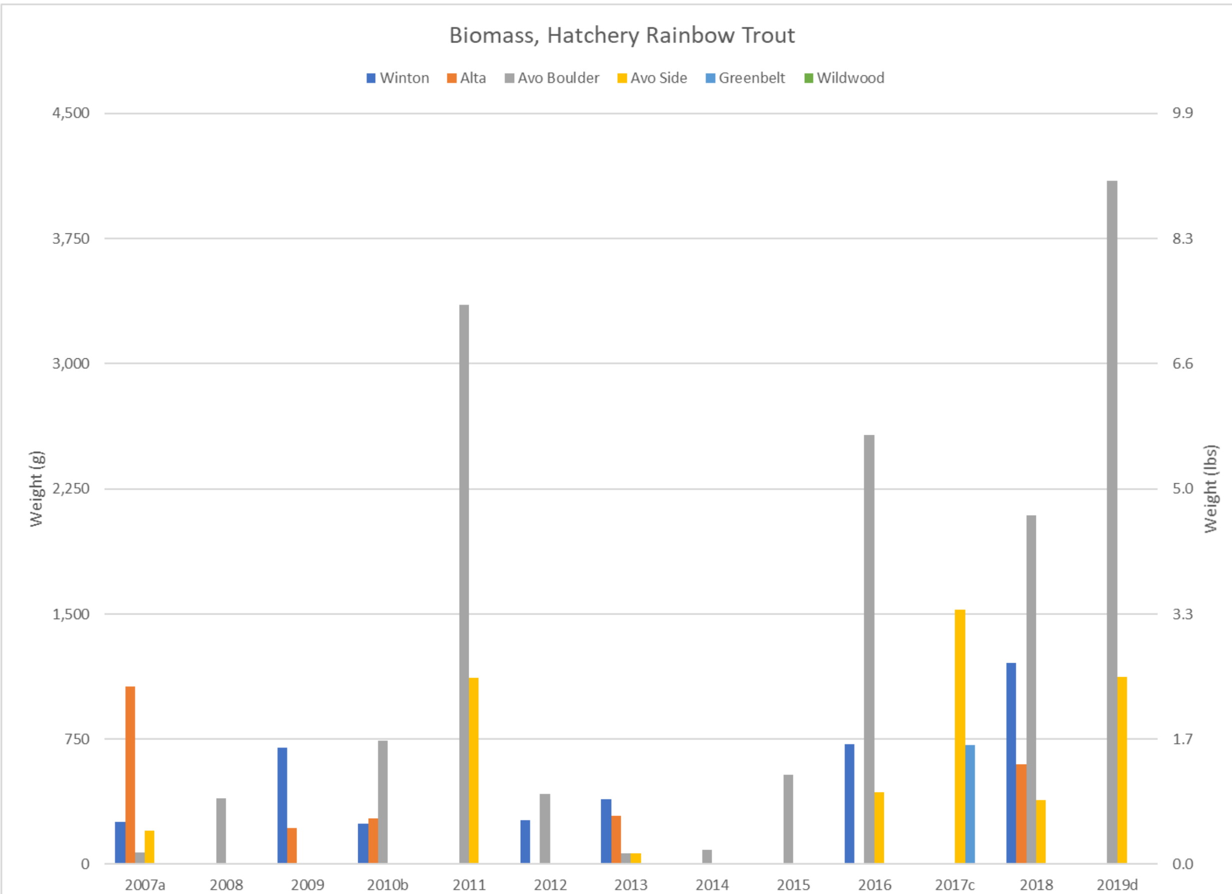

Figure 41. ***Biomass of captured hatchery rainbow trout per site for each Fall Population Electrofishing Survey, 2007-2019. Note that in 2007a nine sites were sampled, and in 2010b eight sites were sampled; data shown only represents that from the six core sites sampled annually. Due to unsafe survey conditions, two sites were sampled in 2017c, and five sites in 2019d.***

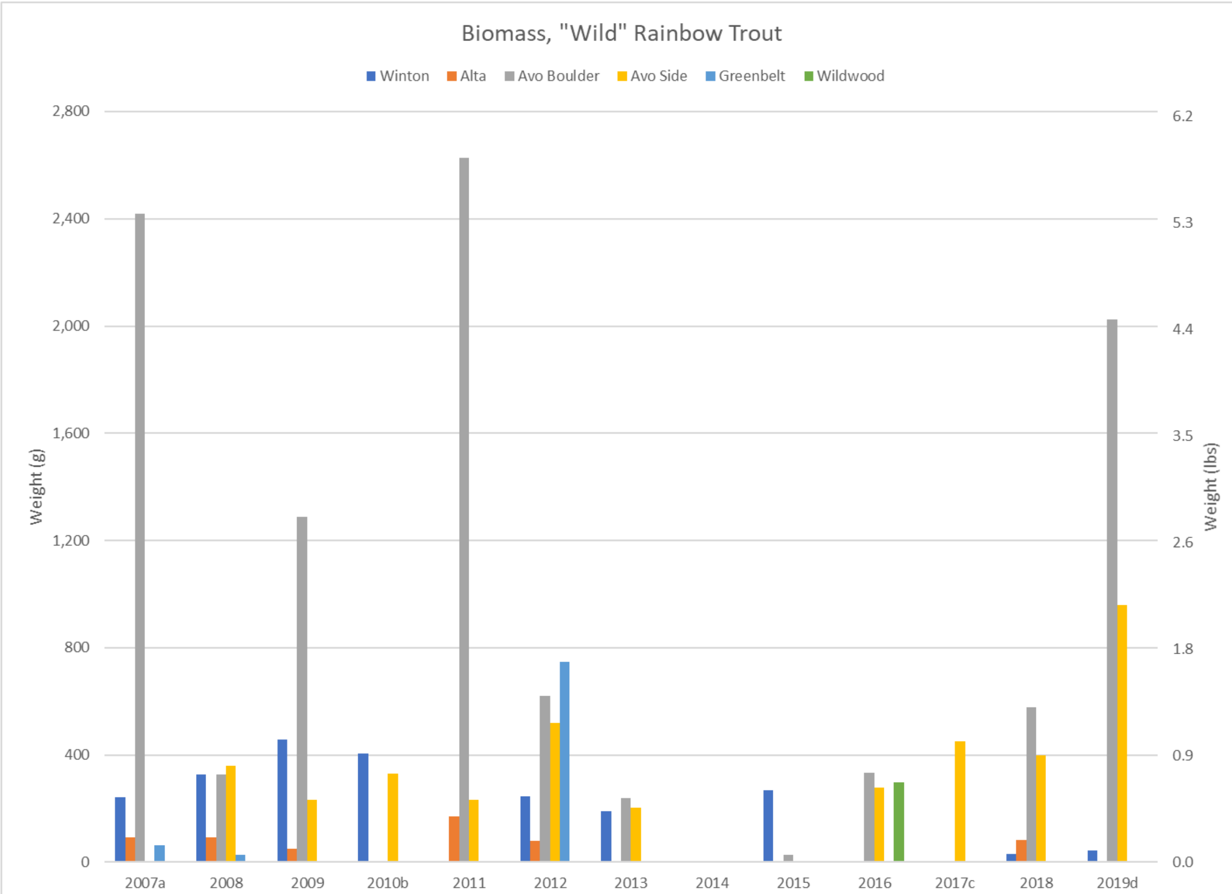

Figure 42. ***Biomass of captured "wild" rainbow trout per site for each Fall Population Electro-fishing Survey, 2007-2019. Note that in 2007a nine sites were sampled, and in 2010b eight sites were sampled; data shown only represents that from the six core sites sampled annually. Due to unsafe survey conditions, two sites were sampled in 2017c, and five sites in 2019d.***

Length-frequency of captured salmonids frequently did not exceed 13 inches, apart from brook trout, which were only captured in 2010. Sixty-seven percent of the brook trout were in the 14 to 15 inch range and 33% in the 15 to 17 inch range. Hatchery rainbow trout ranged in size from 4 to 20 inches, with 23% of the fish less than 6 inches and 80% of the captured fish less than 12 inches (Figure 43). For "wild" rainbow trout, length ranged from 4 to 22 inches with 22% of the fish less than 6 inches and 96% less than 12 inches (Figure 44). Length-frequency data collected during the population surveys shows the most abundant size class collected over time to be like that collected by Hellmair et al. (2020) in a snorkel survey of the Kings River in the fall of 2019. While their data was for only one year, they found the smallest sized trout class, those less than 6 inches (150 mm) to be least abundant in the river, the largest size class of greater than 12 inches (300 mm) the next most abundant, while those in between 6 and 12 inches (150-300 mm) were most abundant. Using the same size classes which were used by Hellmair et al. in their survey, thirteen years of sampling data for combined hatchery and "wild" rainbow trout captures breaks down to 63 trout less than 6 inches (150 mm), 209 trout 6 to 12 inches (150-300 mm), and 36 trout greater than 12 inches (300 mm). While results of the electro-fishing population survey show the largest size class to be least abundant in contrast to those found by Hellmair et al. (2020), this is not to be unexpected as larger fish may be easier to detect while floating downstream due to their size and the snorkel survey was able to survey a greater variety of habitats, including those of deeper waters where larger trout may be present.

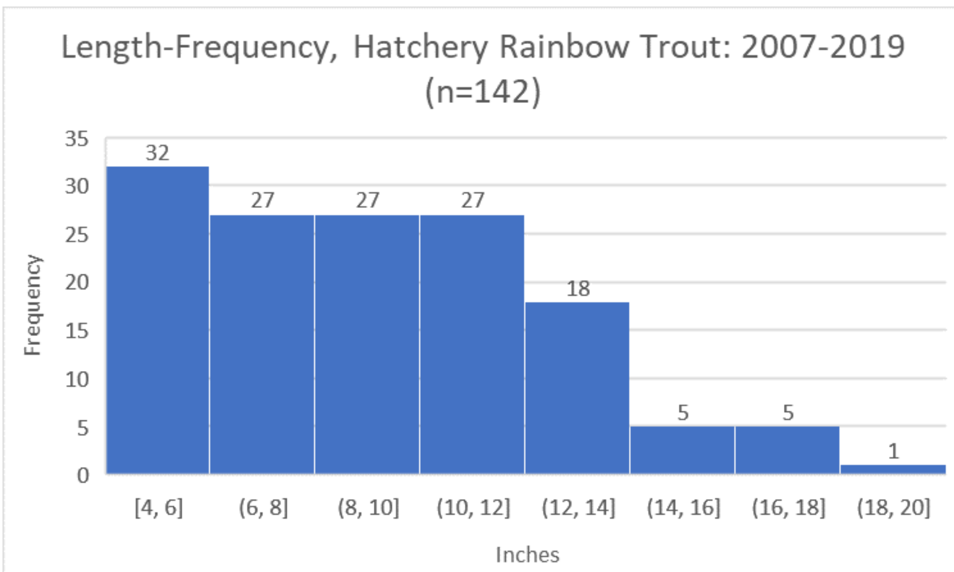

Figure 43. ***Length-frequency of hatchery rainbow trout captured during the Fall Population Electro-fishing Surveys, 2007-2019. The number of fish in each size class is shown.***

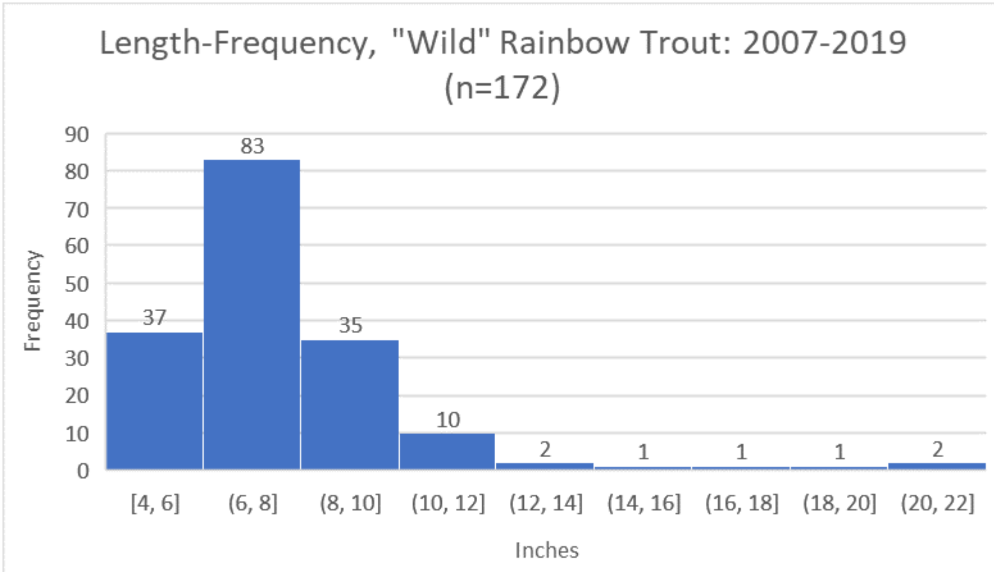

Figure 44. ***Length-frequency of "wild" rainbow trout captured during the Fall Population Electro-fishing Surveys, 2007-2019. The number of fish in each size class is shown.***

The calculated Fulton's condition factor (K-factor) of individual captured salmonids ranged from poor (less than one) to good (greater than one). Minimum, maximum, and mean K-factor is presented in Table 13 by species. Brook trout were captured in only 2010, with seven of the nine fish captured in the Alta site, and the other two fish were captured in Avo Side and Winton. Due to the small sample size, K-factor by site is not presented, but all brook trout were in good condition, with a K-factor greater than 1.0 at time of capture (Table 13). The K-factor by site for hatchery rainbow trout and "wild" rainbow trout is presented in 45 and 46 respectively. For all salmonids, the mean K-factor indicates trout in the Kings River are in good condition (Table 13). For hatchery rainbow trout, mean and median K-factor is 1.0 or greater in all sites except Alta (mean = 0.9, median = 0.8) and Avo Side (mean = 0.9, median = 1.0) (Figure 45). For all individual trout, values less than 1.0 may be reflective of errors in data recording or accuracy of measurements, poor environmental conditions, or energetic demands. It would be hypothesized that hatchery rainbow trout would have a K-factor of 1.0 or greater due to rearing in a controlled environment prior to release. For hatchery rainbow trout, values less than 1.0 may reflect length of time between the stocking event and time of capture. It has been suggested that the number of days from stocking event to capture date may influence condition factor of hatchery rainbow trout due to poor adaptability to river conditions from the hatchery environment (Araki et al. 2008, Araki & Schmid 2010, Olla et al. 1998). Energetic demands, due to movement away from the stocking location may also be reflected in condition factors less than 1.0 as no electro-fishing site is immediately adjacent to a stocking location, and most are downstream of a stocking location. The Alta site, which is in the closest proximity to a stocking location at 0.1 miles is also upstream of the stocking location. For fish dispersing downstream, it could be hypothesized that energetic demands will not be as great if they are swimming with the current. "Wild" rainbow trout, captured in the Kings River had both a mean and median K-factor greater than 1.0, except at Greenbelt, which had a mean and median of 0.9 (Figure 46). For Greenbelt, this poorer condition factor may be due to increased thermal stresses during the later summer and fall as K-factor values at other sites indicate the "wild" trout are well adapted to the Kings River and suggests that food is not a limiting factor for the "wild" rainbow trout population.

Table 13. ***Minimum, maximum, mean, and median calculated Fulton's condition factor (K-factor) for trout captured during the Fall Population Electro-fishing Surveys, 2007-2019.***

Species	Sample Size (n=)	Condition Factor			
		Minimum	Maximum	Mean	Median
Brook Trout	9	1.2	1.9	1.7	1.8
Hatchery Rainbow Trout	142	0.3	1.4	1.0	1.0
"Wild" Rainbow Trout	172	0.1	1.6	1.1	1.1

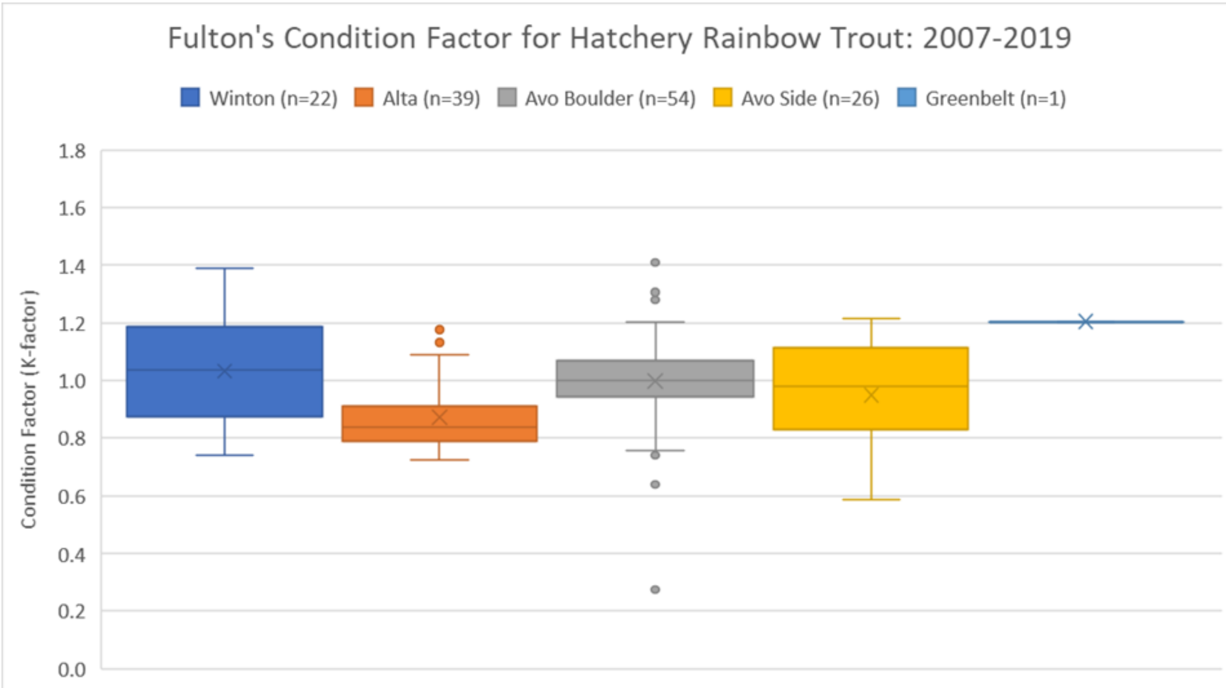

Figure 45. ***Box plot of the calculated Fulton's K-factor by site for hatchery rainbow trout collected during the Fall Population Electro-fishing Surveys, 2007-2019. The box indicates the condition factor for 50% of collected fish, and the range of condition factors 25% to 75% for all collected fish. Outliers are indicated by points outside of the 25% to 75% range. The "X" indicates the mean, while the median is represented by a line within the box.***

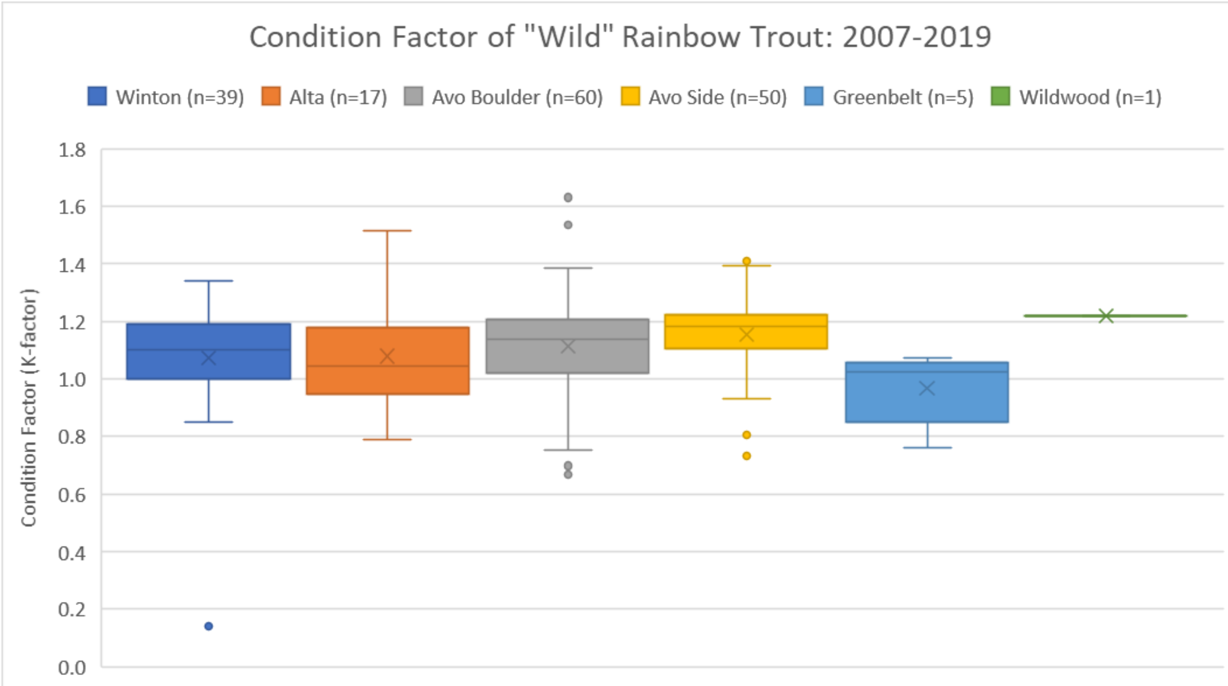

Figure 46. ***Box plot of the calculated Fulton's K-factor by site for "wild" rainbow trout collected during the Fall Population Electro-fishing Surveys, 2007-2019. The box indicates the condition factor for 50% of collected fish, and the range of condition factors 25% to 75% for all collected fish. Outliers are indicated by points outside of the 25% to 75% range. The "X" indicates the mean, while the median is represented by a line within the box.***

Regression analysis allows another means to look at condition factor by analyzing the relationship between length-weight data. The relationship between length-weight data for the Kings River indicates a strong and positive relationship for trout in the Kings River (Figure 47, Figure 48). The regression slope approaches or exceeds 3.0, supporting the finding of the K-factor that these salmonids are in good condition. For brook trout the regression slope was 4.32 (R^2 = 0.80), hatchery rainbow trout was 3.09 (R^2 = 0.97), and "wild" rainbow trout was 2.99 (R^2 = 0.93).

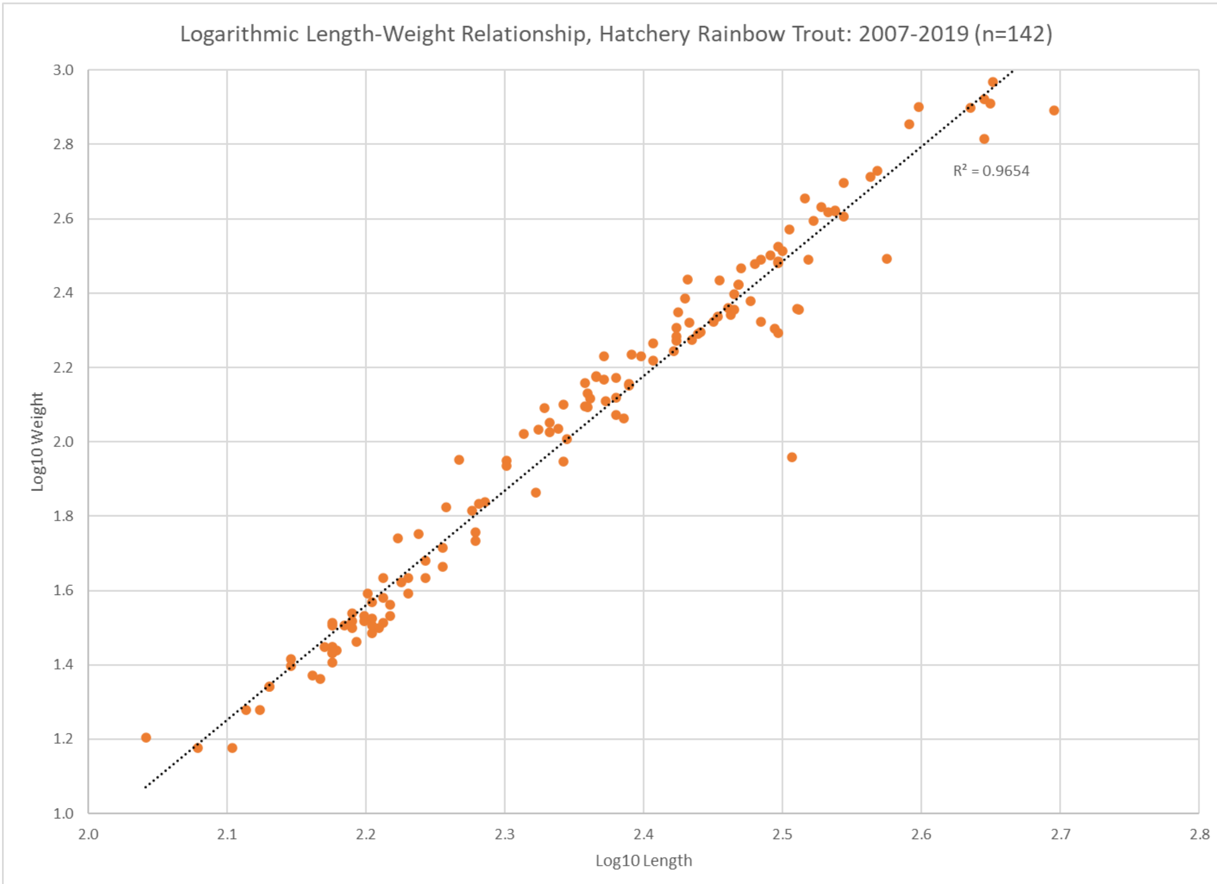

Figure 47. ***Logarithmic length-weight relationship for hatchery rainbow trout captured during the Fall Population Electro-fishing Surveys, 2007-2019.***

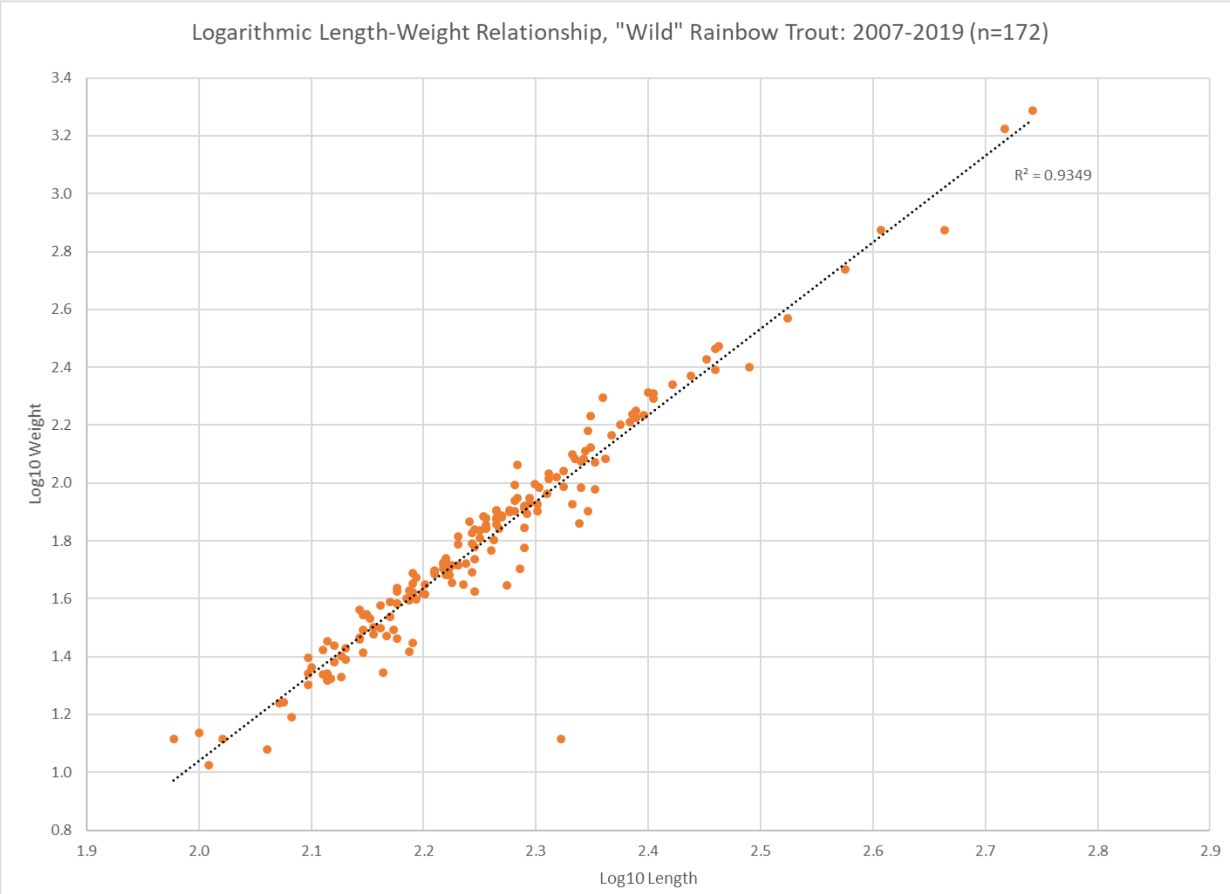

Figure 48. ***Logarithmic length-weight relationship for "wild" rainbow trout captured during the Fall Population Electro-fishing Surveys, 2007-2019.***

SUMMARY

Data collected during the Fall Population Electro-fishing Surveys provides a means to estimate populations throughout the reach. For these surveys, species were collected, identified, and enumerated, providing a snapshot of the assemblage present in the Kings River between Pine Flat Dam and Highway 180. Additional in situ environmental and habitat variables were not measured at the times of the surveys.

Thirteen years of multi-pass depletion surveys indicate that native fishes continue to dominate the river between Pine Flat Dam and Highway 180. On average, by abundance, they make up 99.0% of the annual collection, with introduced fish species accounting for the remainder. From 2012 through 2019 the KRFMP utilized deliberate voltage adjustment of the electro-fishers by site for concurrence with water conductivity. It is not certain how this change in voltage adjustments may have influenced catch efficiency and the interpretation of trends over time in survey results. Catch results do show that while populations of the different species fluctuated over the years, the assemblage continues to be dominated by native Sacramento suckers, sculpin, and cyprinid species. These fish most accurately meet the criteria of the pikeminnow-hardhead-sucker assemblage, which is indicated upstream of Pine Flat Reservoir, then that of the deep-bodied fishes assemblage, indicated below Pine Flat Dam by Moyle (2002). While deep-bodied fishes were present, they typically comprised less than one percent of the species assemblage in most years. Trout were present but were typically no more than one percent of the species assemblage, as expected for a low elevation, low gradient, fish assemblage. Additionally, catch results indicate the successful reproduction for native species as both juvenile and adult life stages are collected for most taxa during the Fall Population Survey. An exception to this being three-spine stickleback, which typically live no more than one year, and all members of the annual cohort have reached adulthood by the time of the population survey. Non-native fish, particularly bass, are also able to successfully reproduce when conditions are suitable, as during the 2012-2016 drought when an increase in the number of young bass was observed.

Sacramento suckers dominate in population surveys for most years. While the population fluctuates over time, this is not uncommon as single cohorts can at times dominate the age structure of the population. Population estimates per site ranged from 14 (95% CI, lower CI adjusted, 13-19) to 1,034 (95% CI, lower CI adjusted, 836-1,232) fish, and estimated fish per mile per site ranged from 246 to 18,198. Lengths of captured fish ranged from 1 to 34 inches, with 76% of Sacramento suckers smaller than 5 inches. Sacramento suckers may be an important keystone species in the Kings River as they may also affect the invertebrate community and juveniles may be an important food source for piscivorous fish and wildlife (Moyle 2002).

Sculpin make up a major component of the fish population in the Kings River and have been the dominant species in some years of the population survey. The population did experience a decline during the 2012-2016 drought but rebounded in later years. Population estimates per site ranged from 1 (95% CI, lower CI adjusted, 1-1) to 877 (95% CI, lower CI adjusted, 812-942) fish, and estimated fish per mile per site ranged from 18 to 15,435. Lengths of captured fish ranged from 1 to 7 inches, with 94% of sculpin smaller than 4 inches.

During the 2012-2016 drought, increases in the native cyprinid species were observed. California roach and Sacramento pikeminnow are the primary cyprinids represented in the Kings River. A single hardhead was captured over 13 years of sampling but may be underrepresented by the population surveys, which may not adequately survey river reaches containing appropriate habitat for them. Population estimates per site for California roach ranged from 0 (95% CI, lower CI adjusted, 0-0) to 1,060 (95% CI, lower CI adjusted, 914-1,206) fish, and estimated fish per mile per site ranged from 0 to 18,656. Lengths of captured fish ranged from 1 to 7 inches, with 22% of California roach smaller than 2 inches and 91% smaller than 4 inches. Population estimates per site for Sacramento pikeminnow ranged from 1 (95% CI, lower CI adjusted, (1-1) to 1,441 (95%, lower CI adjusted, 378-2,952) fish, and estimated fish per mile per site ranged from 18 to 25,362. Lengths of captured fish ranged from 1 to 19 inches, with 82% of Sacramento pikeminnow smaller than 4 inches and 97% smaller than 6 inches. Sacramento pikeminnows may be an important keystone species in the Kings River where they are a top predator. Those smaller than 4 inches (10 cm) feed predominantly on aquatic insects and over 8 inches (20 cm) they become almost exclusively piscivorous. While they are insectivorous in younger age classes, there is also little dietary overlap with salmonids due to habitat partitioning (Merz and Vanicek 1996). And, despite their reputation, Sacramento pikeminnow have been found to not be a significant predator of salmonids (Vondracek and Moyle 1982). Under conditions where movements are not restricted, non-salmonids are primarily consumed (Moyle 2002). Juvenile salmonids, it was found, were taken more frequently in the summer when movement was restricted by anthropogenic barriers (Tucker et al. 1998). This would suggest that diet is largely a function of what is available where Sacramento pikeminnow are present.

Lamprey are found in much of the Kings River. Population estimates per site ranged from 0 (95% CI, lower CI adjusted, 0-0) to 407 (95% CI, lower CI adjusted, 202-624) fish, and estimated fish per mile per site ranged from 0 to 7,163. Lengths of captured lamprey ranged from 2 to 7 inches, with 68% of lamprey in the 5 to 6 inch range.

Three-spine stickleback are a small but steady component of the Kings River, with increases seen during the 2012-2016 drought. Population estimates per site ranged from 0 (95% CI, lower CI adjusted, 0-0) to 559 (95% CI, lower CI adjusted, 129-1,750) fish, and estimated fish per mile per site ranged from 0 to 9,838. Lengths of captured fish ranged from 1 to 4 inches with 99% of three-spine stickleback smaller than 2 inches.

Trout origins can be difficult to distinguish and may cause some hatchery rainbow trout to be misclassified as "wild" rainbow trout. While fin condition, color, the presence/absence of an adipose fin have all been used to distinguish these classes, hatchery rainbow trout which have become resident may take on coloration like the "wild" rainbow trout and worn fins will regenerate over time, possibly leading to misclassification. Additionally, no phenotypic distinction can be made between trout hatched in the incubator and those which were spawned instream. Due to the young age at release, five to seven weeks post-hatch, incubator-hatched fry rear under the same conditions as resident wild trout fry, making fin condition and color an unreliable indicator of origin, thus increasing the potential for misclassification of these hatchery rainbow trout as "wild" rainbow trout.

The "wild" rainbow trout population is small but persistent in the Kings River. During the 2012-2016 drought the "wild" rainbow trout population did experience a decline, with no "wild" trout captured in 2014, but showed signs of recovery to pre-drought levels in later years. Population estimates per site ranged from 0 (95% CI, lower CI adjusted, 0-0) to 24 (95% CI, lower CI adjusted, 7-200) fish while estimated fish per mile per site ranged from 0 to 422. Lengths of captured "wild" trout ranged from 4 to 22 inches with 22% of the fish less than 6 inches and 96% less than 12 inches. Length-weight regression analysis and calculations using Fulton's condition factor both indicate "wild" rainbow trout in the Kings River are in good condition.

CDFW provides an annual allotment for trout stocking in the Kings River, and in 2017 the KRFMP developed a supplemental rainbow trout stocking plan which was approved by the Executive Committee (ExCom) of the KRFMP in 2018 (KRFMP 2018). This plan was implemented in the fall of 2018 and consists of stocking 16,000 pounds (up to ~48,000 fish) of catchable sized rainbow trout annually between October and March. For the purposes of the KRFMP catchable sized trout are 3 fish/lb (10 to 13 inches long), and super-catchable trout are between 1.5 to 2.5 lbs/fish (16 to 19 inches long). These fish are in addition to those stocked regularly as part of the CDFW annual allotment and are released weekly during the supplemental stocking period at a ratio of 75% in the put-and-take zone between the ACOE Bridge on Pine Flat Road and Alta (Cobbles) Weir, and the remaining 25% stocked into the catch-and-release zone behind Avocado Lake.

Hatchery rainbow trout are detected annually and are distinguished from "wild" rainbow trout by either exhibiting abraded or missing fins from rearing in the hatchery or triploid blood cells are observed. Population estimates ranged from 0 (95% CI, lower CI adjusted, 0-0) to 41 (95% CI, lower CI adjusted, 26-79) fish while estimated fish per mile ranged from 0 to 722. Lengths of captured hatchery rainbow trout ranged from 4 to 20 inches with 23% of the fish less than 6 inches and 80% less than 12 inches. Length-weight regression analysis and calculations using Fulton's condition factor both indicate hatchery rainbow trout in the Kings River are in good condition. Results from electro-fishing suggest there may be an increase in hatchery rainbow trout present in the river since implementation of the supplemental stocking plan.

Brook trout and hatchery rainbow trout are both hatchery produced products stocked into the Kings River below Pine Flat Dam. They may be stocked as fingerlings, sub-catchables, catchables, super-catchables, and trophy trout, although not all size classes or species are stocked in all years (Appendix D: Table D1). The species, quantity, density, and size of these hatchery produced trout may be influenced by stocking practices. They are most commonly present in electro-fishing sites which are near regularly stocked locations above Fresno Weir. Stocking locations range from 0.1 to 0.7 miles away from the four sample sites located above Fresno Weir. Below Fresno Weir the river is occasionally stocked; with the closest stocking location to an electro-fishing site being at Highway 180, 0.6 miles downstream of the southernmost sample site. Population estimates for hatchery trout may be lower than expected considering frequency of stocking events. Low population estimates suggest: 1) poor dispersal from stocking locations, 2) angler pressure is high, 3) high predation by piscivorous fish & wildlife, 4) survival of hatchery trout upon release is poor, or 5) some combination of these factors.

Of the introduced non-native fish, bass of the *Micropterus* genera are the most frequently detected in the Kings River. Bass population estimates per site ranged from 0 (95% CI, lower CI adjusted, 0-0) to 56 (95% CI, lower CI adjusted, 55-59) fish, and estimated fish per mile per site ranged from 0 to 986. Lengths of captured fish ranged from 2 to 11 inches, and 88% of bass were smaller than 5 inches. Also detected were bluegill, catfish, green sunfish, and western mosquitofish but in very low numbers. Increases in these species were observed during the 2012-2016 drought.

Additionally, the KRFMP should remain vigilant to the presence of invasive species. Live bait released by anglers could potentially become resident in the Kings River, providing additional competition for native species, and already established introduced species. Golden shiner (*Notemigonus crysoleucas*) (Table 1) and anecdotal observations of threadfin shad (*Dorosoma petenense)* indicate the potential for these bait species to be found in the Kings River below Pine Flat Dam. Invasive mollusks are another threat which could easily infiltrate the Kings River through the recreational use of Pine Flat Reservoir or the Kings River. Asian Clams (*Corbicula fluminea*) are the only invasive mollusk currently known to be present in the Kings River watershed. Quagga (*Dreissena rostriformis bugensis*) and zebra mussels (*D. polymorpha*) have not been detected, although they may be introduced through their illegal use as bait, from wet fishing gear containing larval life stages, or from boats transporting all life stages. Quagga mussels have become well established in several parts of southern California, while zebra mussels in California are believed to be present only in San Justo Reservoir. New Zealand mudsnails (*Potamopyrgus antipodarum*) have also not been detected in the Kings River; they are another threat which has been observed in many waterways in California and due to their small size can be easily overlooked and accidentally transferred between watersheds by anglers and other recreational users. All these invasive mollusks have the potential to interfere with existing food webs, and severe mussel infestations can damage or interfere with the function of infrastructure located within a waterbody or dependent on receipt of water from that waterbody (CDFW 2021, USDA 2021a, USDA 2021b, USGS 2021). All users of the Kings River should take care to not transport these invaders from other water bodies into the Kings River by inspecting gear used in other watersheds for aquatic hitchhikers and/or drying and decontaminating gear prior to use.

Fluctuations in fish populations are normal. While native fish continue to dominate the species assemblage throughout the Kings River below Pine Flat Dam, years when release temperatures were warmer, and instream flows lesser and of shorter duration a moderate increase of non-native fish was observed. It is unlikely variations in species composition can be attributed to any single cause and more likely a combination of environmental and anthropogenic factors influences the fishery population. The KRCD and the KRFMP will continue monitoring and investigating environmental and population variables within the tailwater fishery.

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APPENDIX A

Electro-fishing Sites, Survey Methods, and Reported Sampling Flows: 1983-2019

Table A1. *Electro-fishing survey sites in the Kings River, length of survey reach, year and sample methodology utilized.*

			Method & Year(s) Sampled		
Reach Name	Location	Length (ft)	Mark-Recapture[1]	Single Pass Census[2]	Multi-Pass Depletion[3]
Alta Weir (aka Site A)	Upstream of Alta Weir in side channel along south bank, separated from main channel by island	1,368	1983-1989	1990-2002, 2004-2006	-
Wonder Valley (aka Site B)	Halfway between Piedra Bridge & Mill Cr Confluence in a side channel along south bank	682	1983-1989	1990-2002, 2004-2006	-
Site C	Between Pine Flat (ACOE) Bridge and dam	869	1983	-	-
Avocado Lake Boulder	Behind Avocado Lake on south side of main fork	656	-	1989-2002, 2004-2006	-
County Park Land Boulder	Greenbelt Parkway	1,122	-	1989-2002, 2004-2006	-
Winton Park Boulder	Downstream of Winton Park	1,578	1989	1989-2000, 2002, 2004-2006	-
Avocado Lake Side Channel	Downstream of Avocado Lake and upstream of Dennis Cut diversion	820	-	1995-2002, 2004-2006	-
Wildwood Site	Off Trout Lake Drive in Wildwood Subdivision	820	-	1995-2002, 2004-2006	-
Alta	Subset of historic Alta Weir site (aka Site A)	300	-	-	2007-2016, 2018
Avo Boulder	Subset of Avocado Lake Boulder site	300	-	-	2007-2016, 2018-2019
Avo Side	Subset of Avocado Lake Side Channel site	300	-	-	2007-2019
Avocado Test	Located behind northwest corner of Avocado Lake, upstream of Avocado Boulder site	300	-	-	2007 & 2010
Doyal's Test	Located behind Piedra Library, upstream of Piedra Bridge	300	-	-	2007 & 2010
Greenbelt	Subset of historic County Park Land Boulder site	300	-	-	2007-2019
Large Woody Debris (LWD) Control	Located near Winton Park but upstream of Winton Park Boulder site	330	-	-	2007
Wildwood	Subset of historic Wildwood site	300	-	-	2007-2016, 2018-2019
Winton	Subset of historic Winton Park Boulder site, west of Thorburn Spawning Channel	300	-	-	2007-2016, 2018-2019

[1] sampling methodology used to determine population estimates, requires at a minimum 1 marking pass & 1 recapture pass

[2] sampling methodology used to obtain indices of abundance for a population

[3] sampling methodology used to determine population estimates through the removal of all biomass present within the sample reach

Table A2. *Electro-fishing surveys in the Kings River, number of sites sampled, sampling method, electro-fishing crews, passes, seine placement, determination of trout origin, species recorded, and species measured. A dash indicates no data, and NA denotes information was not available.*

Year[1,2]	Number of Sites Sampled	Total Distance Sampled (ft)	Sampling Method Utilized	Number of Electro-fishing Crews	Number of Passes	Block Seine Net Placement	"Wild" Trout Determinator	Species Recorded	Species Measured
1983	3	2,919	single census mark-recapture	3	2-3	Upstream & Downstream	fin condition	all trout	wild rainbow trout $\geq$ 10 cm FL
1984	2	2,050	single census mark-recapture	2	2	Upstream & Downstream	fin condition	all trout	wild rainbow trout $\geq$ 10 cm FL
1985	2	2,050	single census mark-recapture	2	1-2	Upstream & Downstream	color & fin condition	all trout	wild rainbow trout $\geq$ 10 cm FL
1986	2	2,050	single census mark-recapture	2-3	2	Upstream & Downstream	color & fin condition	all trout	wild rainbow trout $\geq$ 10 cm FL
1987	2	2,050	single census mark-recapture	3	1-2	Upstream & Downstream	color & fin condition	all trout	wild rainbow trout $\geq$ 10 cm FL
1988	2	2,050	single census mark-recapture	2-3	2-3	Upstream & Downstream	color & fin condition	all trout	wild rainbow trout $\geq$ 10 cm FL
1989	3	3,628	single census mark-recapture	3-4	2	Upstream & Downstream	color & fin condition	all trout, others noted	wild rainbow trout $\geq$ 10 cm FL
1989	3	3,356	single pass census	3-4	1	Upstream & Downstream	color & fin condition	all trout, others noted	wild rainbow trout $\geq$ 10 cm FL
1990	5	5,406	single pass census	2-3	1	Upstream & Downstream	color & fin condition	all species	wild rainbow trout $\geq$ 10 cm FL
1991	5	5,406	single pass census	3-4	1	Upstream & Downstream	color & fin condition	all species	wild rainbow trout $\geq$ 10 cm FL
1992	5	5,406	single pass census	2-4	1	Upstream & Downstream	color & fin condition	all species	wild rainbow trout $\geq$ 10 cm FL
1993	5	5,406	single pass census	3-4	1	Upstream & Downstream	color & fin condition, absence of tags/dyes	all species	all rainbow trout
1994	5	5,406	single pass census	4-5	1	Upstream & Downstream	color & fin condition, absence of tags/dyes	all species	all rainbow trout
1995	7	7,046	single pass census	3-5	1	Upstream Only	color & fin condition, absence of tags/dyes	all species	all rainbow trout
1996	7	7,046	single pass census	4-6	1	Upstream Only	color & fin condition, absence of tags/dyes	all species	all rainbow trout
1997	7	7,046	single pass census	3-5	1	Upstream Only	color & fin condition, absence of tags/dyes	all species	all rainbow trout
1998	7	7,046	single pass census	3-5	1	Upstream Only	color & fin condition, absence of tags/dyes, size	all species	all rainbow trout
1999	7	7,046	single pass census	3-5	1	Upstream Only	color & fin condition	all species	all rainbow trout
2000	7	7,046	single pass census	4-6	1	Upstream Only	color & fin condition	all species	all rainbow trout
2001	6	5,468	single pass census	5-6	1	Upstream Only	color & fin condition	all species	all rainbow trout
2002	7	7,046	single pass census	3-7	1	Upstream Only	color & fin condition	all species	all rainbow trout
2003	0	0	not sampled	-	-	-	-	-	-
2004	7	7,046	single pass census	3-6	1	Upstream Only	color & fin condition	all species	all rainbow trout
2005	7	7,046	single pass census	NA	1	Upstream Only	color & fin condition	all species	all rainbow trout
2006	7	7,046	single pass census	NA	1	Upstream Only	color & fin condition	all species	all rainbow trout
2007	9	2,730	mutli-pass depletion survey	5-7	3	Upstream & Downstream	fin condition	all species	all species
2008	6	1,800	mutli-pass depletion survey	6-7	3	Upstream & Downstream	fin condition	all species	all species
2009	6	1,800	mutli-pass depletion survey	6-8	3	Upstream & Downstream	fin condition	all species	all species
2010	8	2,400	mutli-pass depletion survey	5-7	3	Upstream & Downstream	fin condition	all species	all species
2011	6	1,800	mutli-pass depletion survey	4-6	3	Upstream & Downstream	fin condition	all species	all species
2012	6	1,800	mutli-pass depletion survey	5-8	3	Upstream & Downstream	fin condition	all species	all species
2013	6	1,800	mutli-pass depletion survey	5-6	3	Upstream & Downstream	fin condition	all species	all species
2014	6	1,800	mutli-pass depletion survey	7-9	3	Upstream & Downstream	fin condition	all species	all species
2015	6	1,800	mutli-pass depletion survey	5-7	3	Upstream & Downstream	fin condition	all species	all species
2016	6	1,800	mutli-pass depletion survey	5-7	3	Upstream & Downstream	fin condition, diploid blood cells	all species	all species
2017	2	600	mutli-pass depletion survey	8	3	Upstream & Downstream	fin condition, diploid blood cells	all species	all species
2018	6	1,800	mutli-pass depletion survey	6-7	3	Upstream & Downstream	color & fin condition	all species	all species
2019	5	1,500	mutli-pass depletion survey	6-7	3	Upstream & Downstream	color & fin condition	all species	all species

[1] from 2007-2011 shocker settings were standardized at 350 volts, 10% duty cycle, and 50 Hz frequency

[2] from 2012 onward shocker settings were set such that voltage utilized matched water conductivity, and were standardized with a 20% duty cycle, and 30 Hz frequency

Table A3. *Electro-fishing Survey Dates and Reported River Flows in the Kings River at the Army Corps of Engineer Bridge. NA denotes the survey occurred but the timeframe within the year is not available. Note that from 2007 through 2019 only the dates of the fall population surveys are included.*

Year	Survey Period	Flow (cfs)[1]	Notes
1983	Nov. 13 - Nov. 21	15 -47	flows reached 138 cfs during survey
1984	Nov. 20 - Nov. 21	41-45	
1985	Oct. 15 - Oct. 16	51-52	
1986	Nov. 5 - Nov. 14	72-73	
1987	Sep. 30 - Nov. 16	49-134	
1988	Nov. 1 - Nov. 2	54-59	
1989	Oct. 17 - Dec. 19	51-54	releases were at 761 cfs above survey reach
1990	Nov. 19 - Nov. 21	74-100	
1991	Nov. 18 - Nov. 22	49-59	
1992	Nov. 5 - Nov. 11	54-103	
1993	Nov. 22 - Dec. 1	39-92	
1994	Nov. 21 - Nov. 29	53-89	
1995	Nov. 27 - Dec. 1	98-100	
1996	Nov. 26 - Dec. 3	58-70	
1997	Nov. 13 - Nov. 18	100-196	
1998	Nov. 3 - Nov. 11	96-762	flows at 40 cfs at Greenbelt & Wildwood
1999	Nov. 9 - Nov. 15	132-156	
2000	Nov. 30 - Dec. 5	112-115	
2001	Nov. 27 - Nov. 30	101-102	
2002	Dec. 4 - Dec. 9	102	
2003	No Survey	-	
2004	Feb. 13 - Feb. 19	101-126	
2005	NA	-	
2006	NA	-	
2007	Nov. 5 - Nov. 16	107	
2008	Nov. 12 - Nov. 19	100-105	
2009	Nov. 9 - Nov. 17	100-268	flows ramped daily during e-fishing in order to achieve safe wading conditions
2010	Nov. 8 - Nov. 19	101-136	decreased flows by 35 cfs for shocking above Fresno Weir, all sampling at ~100 cfs
2011	Nov. 28 - Dec. 1	105	flows ramped daily during e-fishing in order to achieve safe wading conditions
2012	Nov. 11 - Nov. 20	100-115	
2013	Nov. 12 - Nov. 19	100	
2014	Nov. 12 - Nov. 19	100-150	
2015	Nov. 3 - Nov. 10	108	
2016	Nov. 9 - Nov. 18	105-116	
2017	Nov. 28 - Nov. 29	281-285	
2018	Nov. 1 - Nov. 8	124-149	
2019	Dec. 2 - Dec. 10	100-184	flows ramped daily during e-fishing in order to achieve safe wading conditions

[1] reported flows at ACOE Bridge (0.5 miles below Pine Flat Dam) as reported in the power plant morning report

APPENDIX B

Species Composition: 2007-2019

Table B1: Species Composition 2007

Species Composition, November 2007*								
	Winton	**Alta**	**Avo Boulder**	**Avo Side**	**Greenbelt**	**Wildwood**	**Total**	**% of Total**
California Roach	3	3	20	22	143	53	**244**	**4.5%**
Lamprey sp.	1	202	5	136	3	4	**351**	**6.5%**
Rainbow Trout - "Wild"	7	4	8	0	3	0	**22**	**0.4%**
Rainbow Trout - Hatchery	9	32	2	5	0	0	**48**	**0.9%**
Sacramento Pikeminnow	93	20	75	156	226	378	**948**	**17.7%**
Sacramento Sucker	326	454	390	248	288	315	**2,021**	**37.6%**
Sculpin sp.	375	450	175	211	209	242	**1,662**	**30.9%**
Three-spine Stickleback	8	31	7	16	0	13	**75**	**1.4%**
Total Fish Captured	**822**	**1,196**	**682**	**794**	**872**	**1,005**	**5,371**	
% of Total	**15%**	**22%**	**13%**	**15%**	**16%**	**19%**		**100%**

* nine sites sampled, but data shown represents only that from the six core sites sampled annually

Table B2: Species Composition 2008

Species Composition, November 2008								
	Winton	**Alta**	**Avo Boulder**	**Avo Side**	**Greenbelt**	**Wildwood**	**Total**	**% of Total**
California Roach	0	6	84	16	226	277	**609**	**23.2%**
Catfish sp.	0	0	1	0	1	0	**2**	**0.1%**
Lamprey sp.	2	47	5	75	2	0	**131**	**5.0%**
Rainbow Trout - "Wild"	7	4	7	8	1	0	**27**	**1.0%**
Rainbow Trout - Hatchery	0	0	1	0	0	0	**1**	**0.0%**
Sacramento Pikeminnow	56	15	143	47	154	94	**509**	**19.4%**
Sacramento Sucker	82	157	227	99	103	16	**684**	**26.0%**
Sculpin sp.	151	133	133	71	29	39	**556**	**21.2%**
Three-spine Stickleback	0	36	20	19	0	31	**106**	**4.0%**
Western Mosquitofish	0	2	0	0	0	0	**2**	**0.1%**
Total Fish Captured	**298**	**400**	**621**	**335**	**516**	**457**	**2,627**	
% of Total	**11%**	**15%**	**24%**	**13%**	**20%**	**17%**		**100%**

Table B3: Species Composition 2009

Species Composition, November 2009								
	Winton	**Alta**	**Avo Boulder**	**Avo Side**	**Greenbelt**	**Wildwood**	**Total**	**% of Total**
Bass sp.	0	0	0	1	3	0	**4**	**0.1%**
Bluegill	0	0	0	0	1	0	**1**	**0.0%**
California Roach	0	93	30	6	52	347	**528**	**19.2%**
Catfish sp.	0	0	0	0	2	0	**2**	**0.1%**
Lamprey sp.	4	57	5	79	1	1	**147**	**5.3%**
Rainbow Trout - "Wild"	5	1	11	2	0	0	**19**	**0.7%**
Rainbow Trout - Hatchery	3	1	0	0	0	0	**4**	**0.1%**
Sacramento Pikeminnow	14	48	60	29	88	152	**391**	**14.2%**
Sacramento Sucker	29	122	232	54	53	19	**509**	**18.5%**
Sculpin sp.	276	275	244	109	85	51	**1,040**	**37.8%**
Three-spine Stickleback	1	39	21	17	5	23	**106**	**3.9%**
Total Fish Captured	**332**	**636**	**603**	**297**	**290**	**593**	**2,751**	
% of Total	**12%**	**23%**	**22%**	**11%**	**11%**	**22%**		**100%**

Table B4: Species Composition 2010

Species Composition, November 2010*								
	Winton	Alta	Avo Boulder	Avo Side	Greenbelt	Wildwood	Total	% of Total
Brook Trout	1	7	0	1	0	0	**9**	**0.3%**
California Roach	6	19	51	5	69	401	**551**	**21.0%**
Lamprey sp.	0	57	7	28	1	5	**98**	**3.7%**
Rainbow Trout - "Wild"	8	0	0	3	0	0	**11**	**0.4%**
Rainbow Trout - Hatchery	1	1	2	0	0	0	**4**	**0.2%**
Sacramento Pikeminnow	11	13	30	7	46	83	**190**	**7.2%**
Sacramento Sucker	41	189	122	42	14	62	**470**	**17.9%**
Sculpin sp.	439	272	195	96	78	87	**1,167**	**44.4%**
Three-spine Stickleback	17	59	4	0	0	46	**126**	**4.8%**
Total Fish Captured	**524**	**617**	**411**	**182**	**208**	**684**	**2,626**	
% of Total	**20%**	**23%**	**16%**	**7%**	**8%**	**26%**		**100%**

* eight sites sampled, but data shown represents only that from the six core sites sampled annually

Table B5: Species Composition 2011

Species Composition, November-December 2011								
	Winton	Alta	Avo Boulder	Avo Side	Greenbelt	Wildwood	Total	% of Total
California Roach	6	7	23	25	26	212	**299**	**16.3%**
Green Sunfish	1	0	0	0	0	0	**1**	**0.1%**
Lamprey sp.	0	48	17	90	0	0	**155**	**8.5%**
Rainbow Trout - "Wild"	0	3	5	2	0	0	**10**	**0.5%**
Rainbow Trout - Hatchery	0	0	6	3	0	0	**9**	**0.5%**
Sacramento Pikeminnow	33	22	9	2	12	8	**86**	**4.7%**
Sacramento Sucker	62	98	68	44	13	77	**362**	**19.7%**
Sculpin sp.	253	213	85	144	60	93	**848**	**46.2%**
Three-spine Stickleback	9	38	9	4	1	3	**64**	**3.5%**
Total Fish Captured	**364**	**429**	**222**	**314**	**112**	**393**	**1,834**	
% of Total	**20%**	**23%**	**12%**	**17%**	**6%**	**21%**		**100%**

Table B6: Species Composition 2012

Species Composition, November 2012								
	Winton	Alta	AvoBoulder	AvoSide	Greenbelt	Wildwood	Total	% of Total
Bass sp.	0	0	0	0	0	1	**1**	**0.0%**
California Roach	0	37	77	30	121	156	**421**	**9.9%**
Catfish sp.	0	0	0	0	1	1	**2**	**0.0%**
Lamprey Sp.	0	103	23	76	4	0	**206**	**4.8%**
Rainbow Trout - "Wild"	6	3	12	6	1	0	**28**	**0.7%**
Rainbow Trout - Hatchery	1	0	3	0	0	0	**4**	**0.1%**
Sacramento Pikeminnow	1	17	44	169	64	133	**428**	**10.0%**
Sacramento Sucker	107	396	336	244	98	510	**1,691**	**39.6%**
Sculpin Sp.	336	391	275	182	104	99	**1,387**	**32.5%**
Three-spine Stickleback	0	36	6	24	4	20	**90**	**2.1%**
Western Mosquitofish	0	0	0	9	0	0	**9**	**0.2%**
Total Fish Captured	**451**	**983**	**776**	**740**	**397**	**920**	**4,267**	
% of Total	**11%**	**23%**	**18%**	**17%**	**9%**	**22%**		**100%**

Table B7: Species Composition 2013

Species Composition, November 2013								
	Winton	Alta	Avo Boulder	Avo Side	Greenbelt	Wildwood	Total	% of Total
Bass sp.	0	0	0	0	5	0	**5**	**0.1%**
California Roach	0	52	179	248	220	444	**1,143**	**19.0%**
Catfish sp.	0	0	0	0	3	0	**3**	**0.0%**
Lamprey sp.	3	35	7	102	3	0	**150**	**2.5%**
Rainbow Trout - "Wild"	3	0	4	4	0	0	**11**	**0.2%**
Rainbow Trout - Hatchery	2	1	1	1	0	0	**5**	**0.1%**
Sacramento Pikeminnow	170	98	333	130	375	759	**1,865**	**31.0%**
Sacramento Sucker	355	257	256	73	51	162	**1,154**	**19.2%**
Sculpin sp.	493	188	291	188	176	130	**1,466**	**24.4%**
Three-spine Stickleback	15	64	6	10	15	101	**211**	**3.5%**
Western Mosquitofish	0	1	0	0	0	0	**1**	**0.0%**
Total Fish Captured	**1,041**	**696**	**1,077**	**756**	**848**	**1,596**	**6,014**	
% of Total	**17%**	**12%**	**18%**	**13%**	**14%**	**27%**		**100%**

Table B8: Species Composition 2014

Species Composition, November 2014								
	Winton	Alta	Avo Boulder	Avo Side	Greenbelt	Wildwood	Total	% of Total
Bass sp.	0	1	1	0	26	1	**29**	**0.7%**
California Roach	23	101	184	100	178	463	**1,049**	**25.7%**
Catfish sp.	2	0	2	2	15	0	**21**	**0.5%**
Lamprey sp.	2	109	40	207	3	1	**362**	**8.9%**
Rainbow Trout - Hatchery	0	0	1	0	0	0	**1**	**0.0%**
Sacramento Pikeminnow	173	48	261	57	117	284	**940**	**23.1%**
Sacramento Sucker	114	89	148	67	34	80	**532**	**13.0%**
Sculpin sp.	360	54	129	81	34	59	**717**	**17.6%**
Three-spine Stickleback	31	219	31	58	4	63	**406**	**10.0%**
Western Mosquitofish	0	1	0	2	3	14	**20**	**0.5%**
Total Fish Captured	**705**	**622**	**797**	**574**	**414**	**965**	**4,077**	
% of Total	**17%**	**15%**	**20%**	**14%**	**10%**	**24%**		**100%**

Table B9: Species Composition 2015

Species Composition, November 2015								
	Winton	Alta	Avo Boulder	Avo Side	Greenbelt	Wildwood	Total	% of Total
Bass sp.	0	1	0	1	55	4	**61**	**1.4%**
California Roach	33	183	292	211	73	720	**1,512**	**35.3%**
Catfish sp.	0	0	0	0	2	0	**2**	**0.0%**
Lamprey sp.	2	107	25	54	0	1	**189**	**4.4%**
Rainbow Trout - "Wild"	1	0	1	0	0	0	**2**	**0.0%**
Rainbow Trout - Hatchery	0	0	1	0	0	0	**1**	**0.0%**
Sacramento Pikeminnow	126	50	200	158	108	158	**800**	**18.7%**
Sacramento Sucker	422	371	289	200	24	23	**1,329**	**31.0%**
Sculpin sp.	160	7	27	4	7	6	**211**	**4.9%**
Three-spine Stickleback	48	31	14	20	0	9	**122**	**2.8%**
Western Mosquitofish	2	23	0	0	13	19	**57**	**1.3%**
Total Fish Captured	**794**	**773**	**849**	**648**	**282**	**940**	**4,286**	
% of Total	**19%**	**18%**	**20%**	**15%**	**7%**	**22%**		**100%**

Table B10: Species Composition 2016

Species Composition, November 2016								
	Winton	Alta	Avo Boulder	Avo Side	Greenbelt	Wildwood	Total	% of Total
Bass sp.	0	0	0	0	15	1	**16**	**0.3%**
Bluegill	0	0	0	0	1	0	**1**	**0.0%**
California Roach	11	327	359	167	89	580	**1,533**	**25.9%**
Green Sunfish	0	0	0	0	2	0	**2**	**0.0%**
Lamprey sp.	3	130	26	138	2	0	**299**	**5.0%**
Rainbow Trout - "Wild"	0	0	2	4	0	1	**7**	**0.1%**
Rainbow Trout - Hatchery	2	0	7	2	0	0	**11**	**0.2%**
Sacramento Pikeminnow	52	72	175	10	40	44	**393**	**6.6%**
Sacramento Sucker	539	391	634	207	488	556	**2,815**	**47.5%**
Sculpin sp.	210	27	24	4	37	1	**303**	**5.1%**
Three-spine Stickleback	92	78	95	129	6	118	**518**	**8.7%**
Western Mosquitofish	0	15	0	0	1	16	**32**	**0.5%**
Total Fish Captured	**909**	**1,040**	**1,322**	**661**	**681**	**1,317**	**5,930**	
% of Total	**15%**	**18%**	**22%**	**11%**	**11%**	**22%**		**100%**

Table B11: Species Composition 2017

Species Composition, November 2017*								
	Winton	Alta	Avo Boulder	Avo Side	Greenbelt	Wildwood	Total	% of Total
Bass sp.	-	-	-	0	3	-	**3**	**0.2%**
California Roach	-	-	-	99	170	-	**269**	**19.8%**
Green Sunfish	-	-	-	0	5	-	**5**	**0.4%**
Lamprey sp.	-	-	-	119	8	-	**127**	**9.4%**
Rainbow Trout - "Wild"	-	-	-	3	0	-	**3**	**0.2%**
Rainbow Trout - Hatchery	-	-	-	4	1	-	**5**	**0.4%**
Sacramento Pikeminnow	-	-	-	14	25	-	**39**	**2.9%**
Sacramento Sucker	-	-	-	322	166	-	**488**	**36.0%**
Sculpin sp.	-	-	-	150	156	-	**306**	**22.6%**
Three-spine Stickleback	-	-	-	29	82	-	**111**	**8.2%**
Total Fish Captured	**-**	**-**	**-**	**740**	**616**	**-**	**1,356**	
% of Total	**-**	**-**	**-**	**55%**	**45%**	**-**		**100%**

* only two sites sampled due to unsafe flows for surveying at other sites

Table B12: Species Composition 2018

Species Composition, November 2018								
	Winton	Alta	Avo Boulder	Avo Side	Greenbelt	Wildwood	Total	% of Total
Bass sp.	0	0	0	1	1	0	**2**	**0.0%**
California Roach	0	5	44	10	64	324	**447**	**8.6%**
Catfish sp.	0	0	0	0	1	0	**1**	**0.0%**
Hardhead	0	0	0	0	1	0	**1**	**0.0%**
Lamprey sp.	2	71	10	153	6	6	**248**	**4.8%**
Rainbow Trout - "Wild"	1	2	7	8	0	0	**18**	**0.3%**
Rainbow Trout - Hatchery	4	4	4	3	0	0	**15**	**0.3%**
Sacramento Pikeminnow	6	11	12	5	142	47	**223**	**4.3%**
Sacramento Sucker	422	390	387	375	174	360	**2,108**	**40.4%**
Sculpin sp.	713	651	142	172	239	143	**2,060**	**39.5%**
Three-spine Stickleback	13	10	16	32	15	10	**96**	**1.8%**
Total Fish Captured	**1,161**	**1,144**	**622**	**759**	**643**	**890**	**5,219**	
% of Total	**22%**	**22%**	**12%**	**15%**	**12%**	**17%**		**100%**

Table B13: Species Composition 2019

Species Composition, December 2019*								
	Winton	**Alta**	**Avo Boulder**	**Avo Side**	**Greenbelt**	**Wildwood**	**Total**	**% of Total**
California Roach	0	-	11	25	8	84	**128**	**7.3%**
Catfish sp.	3	-	0	2	1	0	**6**	**0.3%**
Lamprey sp.	4	-	5	166	2	8	**185**	**10.5%**
Rainbow Trout - "Wild"	1	-	3	10	0	0	**14**	**0.8%**
Rainbow Trout - Hatchery	0	-	26	8	0	0	**34**	**1.9%**
Sacramento Pikeminnow	23	-	6	4	21	8	**62**	**3.5%**
Sacramento Sucker	44	-	174	155	53	158	**584**	**33.1%**
Sculpin sp.	339	-	67	168	69	68	**711**	**40.3%**
Three-spine Stickleback	8	-	13	9	5	5	**40**	**2.3%**
Total Fish Captured	**422**	**-**	**305**	**547**	**159**	**331**	**1,764**	
% of Total	**24%**	**-**	**17%**	**31%**	**9%**	**19%**		**100%**

* only five sites sampled due to adverse weather at Alta creating unsafe survey conditions

APPENDIX C

Fish Catch-per-Unit Effort (CPUE): 2007-2019

Table C1: CPUE 2007

CPUE (fish/hr), November 2007*							
	Winton	Alta	Avo Boulder	Avo Side	Greenbelt	Wildwood	Overall
California Roach	0.39	0.33	2.68	3.08	16.23	7.52	5.19
Lamprey sp.	0.13	22.49	0.67	19.05	0.34	0.57	7.46
Rainbow Trout - "Wild"	0.92	0.45	1.07	0.00	0.34	0.00	0.47
Rainbow Trout - Hatchery	1.18	3.56	0.27	0.70	0.00	0.00	1.02
Sacramento Pikeminnow	12.20	2.23	10.07	21.85	25.65	53.60	20.15
Sacramento Sucker	42.78	50.55	52.35	34.73	32.69	44.67	42.95
Sculpin sp.	49.21	50.10	23.49	29.55	23.72	34.32	35.32
Three-spine Stickleback	1.05	3.45	0.94	2.24	0.00	1.84	1.59

* nine sites sampled, but data shown represents only that from the six core sites sampled annually

Table C2: CPUE 2008

CPUE (fish/hr), November 2008							
	Winton	Alta	Avo Boulder	Avo Side	Greenbelt	Wildwood	Overall
California Roach	0.00	1.02	12.74	2.82	29.54	41.34	15.50
Catfish sp.	0.00	0.00	0.15	0.00	0.13	0.00	0.05
Lamprey sp.	0.29	8.01	0.76	13.22	0.26	0.00	3.33
Rainbow Trout - "Wild"	1.03	0.68	1.06	1.41	0.13	0.00	0.69
Rainbow Trout - Hatchery	0.00	0.00	0.15	0.00	0.00	0.00	0.03
Sacramento Pikeminnow	8.23	2.56	21.68	8.29	20.13	14.03	12.95
Sacramento Sucker	12.05	26.77	34.42	17.45	13.46	2.39	17.41
Sculpin sp.	22.18	22.67	20.16	12.52	3.79	5.82	14.15
Three-spine Stickleback	0.00	6.14	3.03	3.35	0.00	1.94	2.24
Western Mosquitofish	0.00	0.34	0.00	0.00	0.00	0.00	0.05

Table C3: CPUE 2009

CPUE (fish/hr), November 2009							
	Winton	Alta	Avo Boulder	Avo Side	Greenbelt	Wildwood	Overall
Bass sp.	0.00	0.00	0.00	0.17	0.34	0.00	0.09
Bluegill	0.00	0.00	0.00	0.00	0.11	0.00	0.02
California Roach	0.00	13.69	3.31	1.02	5.82	56.94	11.87
Catfish sp.	0.00	0.00	0.00	0.00	0.22	0.00	0.04
Lamprey sp.	0.52	8.39	0.55	13.38	0.11	0.16	3.31
Rainbow Trout - "Wild"	0.65	0.15	1.21	0.34	0.00	0.00	0.43
Rainbow Trout - Hatchery	0.39	0.15	0.00	0.00	0.00	0.00	0.09
Sacramento Pikeminnow	1.82	7.06	6.62	4.91	9.85	24.94	8.79
Sacramento Sucker	3.77	17.95	25.60	9.15	5.93	3.12	11.44
Sculpin sp.	35.92	40.47	26.92	18.46	9.51	8.37	23.38
Three-spine Stickleback	0.13	5.74	2.32	2.88	0.56	3.77	2.38

Table C4: CPUE 2010

CPUE (fish/hr), November 2010*							
	Winton	**Alta**	**Avo Boulder**	**Avo Side**	**Greenbelt**	**Wildwood**	**Overall**
Brook Trout	0.12	1.10	0.00	0.24	0.00	0.00	0.23
California Roach	0.71	2.99	7.38	1.20	13.09	54.46	14.29
Lamprey sp.	0.00	8.96	1.01	6.72	0.19	0.68	2.54
Rainbow Trout - "Wild"	0.94	0.00	0.00	0.72	0.00	0.00	0.29
Rainbow Trout - Hatchery	0.12	0.16	0.29	0.00	0.00	0.00	0.10
Sacramento Pikeminnow	1.29	2.04	4.34	1.68	8.73	11.27	4.93
Sacramento Sucker	4.83	29.70	17.66	10.07	2.66	8.42	12.19
Sculpin sp.	51.67	42.74	28.23	23.02	14.80	11.82	30.26
Three-spine Stickleback	2.00	9.27	0.58	0.00	0.00	6.25	3.27

* eight sites sampled, but data shown represents only that from the six core sites sampled annually

Table C5: CPUE 2011

CPUE (fish/hr), November-December 2011							
	Winton	**Alta**	**Avo Boulder**	**Avo Side**	**Greenbelt**	**Wildwood**	**Overall**
California Roach	0.73	1.49	2.70	5.58	4.05	28.76	7.52
Green Sunfish	0.12	0.00	0.00	0.00	0.00	0.00	0.03
Lamprey sp.	0.00	10.22	1.99	20.08	0.00	0.00	3.90
Rainbow Trout - "Wild"	0.00	0.64	0.59	0.45	0.00	0.00	0.25
Rainbow Trout - Hatchery	0.00	0.00	0.70	0.67	0.00	0.00	0.23
Sacramento Pikeminnow	4.00	4.68	1.05	0.45	1.87	1.09	2.16
Sacramento Sucker	7.52	20.86	7.97	9.82	2.02	10.45	9.11
Sculpin sp.	30.69	45.34	9.96	32.13	9.34	12.62	21.33
Three-spine Stickleback	1.09	8.09	1.05	0.89	0.16	0.41	1.61

Table C6: CPUE 2012

CPUE (fish/hr), November 2012							
	Winton	**Alta**	**Avo Boulder**	**Avo Side**	**Greenbelt**	**Wildwood**	**Overall**
Bass sp.	0.00	0.00	0.00	0.00	0.00	0.13	0.02
California Roach	0.00	3.19	9.08	4.01	15.21	20.01	8.23
Catfish sp.	0.00	0.00	0.00	0.00	0.13	0.13	0.04
Lamprey sp.	0.00	8.88	2.71	10.15	0.50	0.00	4.03
Rainbow Trout - "Wild"	0.77	0.26	1.41	0.80	0.13	0.00	0.55
Rainbow Trout - Hatchery	0.13	0.00	0.35	0.00	0.00	0.00	0.08
Sacramento Pikeminnow	0.13	1.47	5.19	22.58	8.05	17.06	8.37
Sacramento Sucker	13.68	34.16	39.61	32.60	12.32	65.43	33.07
Sculpin sp.	42.96	33.73	32.42	24.32	13.08	12.70	27.13
Three-spine Stickleback	0.00	3.11	0.71	3.21	0.50	2.57	1.76
Western Mosquitofish	0.00	0.00	0.00	1.20	0.00	0.00	0.18

Table C7: CPUE 2013

CPUE (fish/hr), November 2013							
	Winton	**Alta**	**Avo Boulder**	**Avo Side**	**Greenbelt**	**Wildwood**	**Overall**
Bass sp.	0.00	0.00	0.00	0.00	0.65	0.00	0.12
California Roach	0.00	8.19	26.12	38.74	28.49	54.65	26.95
Catfish sp.	0.00	0.00	0.00	0.00	0.39	0.00	0.07
Lamprey sp.	0.43	5.51	1.02	15.94	0.39	0.00	3.54
Rainbow Trout - "Wild"	0.43	0.00	0.58	0.62	0.00	0.00	0.26
Rainbow Trout - Hatchery	0.29	0.16	0.15	0.16	0.00	0.00	0.12
Sacramento Pikeminnow	24.42	15.44	48.58	20.31	48.56	93.42	43.97
Sacramento Sucker	50.99	40.49	37.35	11.40	6.60	19.94	27.21
Sculpin sp.	70.81	29.62	42.46	29.37	22.79	16.00	34.57
Three-spine Stickleback	2.15	10.08	0.88	1.56	1.94	12.43	4.97
Western Mosquitofish	0.00	0.16	0.00	0.00	0.00	0.00	0.02

Table C8: CPUE 2014

CPUE (fish/hr), November 2014							
	Winton	**Alta**	**Avo Boulder**	**Avo Side**	**Greenbelt**	**Wildwood**	**Overall**
Bass sp.	0.00	0.13	0.13	0.00	3.65	0.13	0.58
California Roach	2.16	12.77	24.48	11.38	24.97	60.30	21.11
Catfish sp.	0.19	0.00	0.27	0.23	2.10	0.00	0.42
Lamprey sp.	0.19	13.79	5.32	23.56	0.42	0.13	7.29
Rainbow Trout - Hatchery	0.00	0.00	0.13	0.00	0.00	0.00	0.02
Sacramento Pikeminnow	16.22	6.07	34.73	6.49	16.41	36.99	18.92
Sacramento Sucker	10.69	11.26	19.69	7.63	4.77	10.42	10.71
Sculpin sp.	33.76	6.83	17.16	9.22	4.77	7.68	14.43
Three-spine Stickleback	2.91	27.70	4.12	6.60	0.56	8.20	8.17
Western Mosquitofish	0.00	0.13	0.00	0.23	0.42	1.82	0.40

Table C9: CPUE 2015

CPUE (fish/hr), November 2015							
	Winton	**Alta**	**Avo Boulder**	**Avo Side**	**Greenbelt**	**Wildwood**	**Overall**
Bass sp.	0.00	0.14	0.00	0.18	7.91	0.49	1.37
California Roach	3.92	25.18	36.06	38.86	10.49	87.58	34.06
Catfish sp.	0.00	0.00	0.00	0.00	0.29	0.00	0.05
Lamprey sp.	0.24	14.72	3.09	9.95	0.00	0.12	4.26
Rainbow Trout - "Wild"	0.12	0.00	0.12	0.00	0.00	0.00	0.05
Rainbow Trout - Hatchery	0.00	0.00	0.12	0.00	0.00	0.00	0.02
Sacramento Pikeminnow	14.97	6.88	24.70	29.10	15.52	19.22	18.02
Sacramento Sucker	50.13	51.06	35.69	36.84	3.45	2.80	29.94
Sculpin sp.	19.01	0.96	3.33	0.74	1.01	0.73	4.75
Three-spine Stickleback	5.70	4.27	1.73	3.68	0.00	1.09	2.75
Western Mosquitofish	0.24	3.17	0.00	0.00	1.87	2.31	1.28

Table C10: CPUE 2016

CPUE (fish/hr), November 2016							
	Winton	**Alta**	**Avo Boulder**	**Avo Side**	**Greenbelt**	**Wildwood**	**Overall**
Bass sp.	0.00	0.00	0.00	0.00	2.41	0.16	0.44
Bluegill	0.00	0.00	0.00	0.00	0.16	0.00	0.03
California Roach	1.51	61.65	53.79	32.39	14.29	95.70	41.75
Green Sunfish	0.00	0.00	0.00	0.00	0.32	0.00	0.05
Lamprey sp.	0.41	24.51	3.90	26.77	0.32	0.00	8.14
Rainbow Trout - "Wild"	0.00	0.00	0.30	0.78	0.00	0.16	0.19
Rainbow Trout - Hatchery	0.27	0.00	1.05	0.39	0.00	0.00	0.30
Sacramento Pikeminnow	7.12	13.57	26.22	1.94	6.42	7.26	10.70
Sacramento Sucker	73.84	73.72	94.99	40.15	78.36	91.74	76.66
Sculpin sp.	28.77	5.09	3.60	0.78	5.94	0.16	8.25
Three-spine Stickleback	12.60	14.71	14.23	25.02	0.96	19.47	14.11
Western Mosquitofish	0.00	2.83	0.00	0.00	0.16	2.64	0.87

Table C11: CPUE 2017

CPUE (fish/hr), November 2017*							
	Winton	**Alta**	**Avo Boulder**	**Avo Side**	**Greenbelt**	**Wildwood**	**Overall**
Bass sp.	-	-	-	0.00	0.31	-	0.17
California Roach	-	-	-	12.47	17.81	-	15.39
Green Sunfish	-	-	-	0.00	0.52	-	0.29
Lamprey sp.	-	-	-	14.99	0.84	-	7.27
Rainbow Trout - "Wild"	-	-	-	0.38	0.00	-	0.17
Rainbow Trout - Hatchery	-	-	-	0.50	0.10	-	0.29
Sacramento Pikeminnow	-	-	-	1.76	2.62	-	2.23
Sacramento Sucker	-	-	-	40.57	17.39	-	27.92
Sculpin sp.	-	-	-	18.90	16.35	-	17.51
Three-spine Stickleback	-	-	-	3.65	8.59	-	6.35

* only two sites sampled due to unsafe flows for surveying at other sites

Table C12: CPUE 2018

CPUE (fish/hr), November 2018							
	Winton	**Alta**	**Avo Boulder**	**Avo Side**	**Greenbelt**	**Wildwood**	**Overall**
Bass sp.	0.00	0.00	0.00	0.16	0.14	0.00	0.04
California Roach	0.00	0.67	6.95	1.57	8.69	37.14	9.22
Catfish sp.	0.00	0.00	0.00	0.00	0.14	0.00	0.02
Hardhead	0.00	0.00	0.00	0.00	0.14	0.00	0.02
Lamprey sp.	0.16	9.53	1.58	23.98	0.81	0.69	5.11
Rainbow Trout - "Wild"	0.08	0.27	1.11	1.25	0.00	0.00	0.37
Rainbow Trout - Hatchery	0.33	0.54	0.63	0.47	0.00	0.00	0.31
Sacramento Pikeminnow	0.49	1.48	1.89	0.78	19.28	5.39	4.60
Sacramento Sucker	34.49	52.33	61.11	58.78	23.62	41.26	43.47
Sculpin sp.	58.27	87.35	22.42	26.96	32.45	16.39	42.48
Three-spine Stickleback	1.06	1.34	2.53	5.02	2.04	1.15	1.98

Table C13: CPUE 2019

CPUE (fish/hr), December 2019*							
	Winton	**Alta**	**Avo Boulder**	**Avo Side**	**Greenbelt**	**Wildwood**	**Overall**
California Roach	0.00	-	1.82	3.59	1.06	12.37	3.53
Catfish sp.	0.34	-	0.00	0.29	0.13	0.00	0.17
Lamprey sp.	0.45	-	0.83	23.85	0.26	1.18	5.10
Rainbow Trout - "Wild"	0.11	-	0.50	1.44	0.00	0.00	0.39
Rainbow Trout - Hatchery	0.00	-	4.29	1.15	0.00	0.00	0.94
Sacramento Pikeminnow	2.59	-	0.99	0.57	2.77	1.18	1.71
Sacramento Sucker	4.95	-	28.72	22.27	6.99	23.28	16.10
Sculpin sp.	38.17	-	11.06	24.13	9.10	10.02	19.60
Three-spine Stickleback	0.90	-	2.15	1.29	0.66	0.74	1.10

* only five sites sampled due to adverse weather at Alta creating unsafe survey conditions

APPENDIX D

Trout Stocking Information: 2007-2019

Table D1. *Number of trout stocked by CDFW, per year and size class, 2007-2019.*

Year	Fingerling	Sub-Catchable	Catchable	Super-Catchable	Trophy	Total Fish
2007	0	25,000	31,264	1,891	1,127	59,282
2008	14,592	2,410	25,328	2,610	1,980	46,920
2009	0	34,579	30,680	2,658	1,492	69,409
2010	10	26,720	34,666	3,775	210	65,381
2011	2,774	27,848	31,088	3,863	0	65,573
2012	22,654	0	33,615	3,655	439	60,363
2013	0	50,219	23,706	3,959	930	78,814
2014	0	30,960	24,967	5,124	0	61,051
2015	0	27,092	11,080	2,509	0	40,681
2016	60	0	36,396	5,822	0	42,278
2017	8,736	0	8,310	5,127	543	22,716
2018	0	0	27,647	833	1,029	29,509
2019	0	43,485	52,303	2,373	0	98,161

Table D2. *Supplemental stocking record for the Kings River below Pine Flat Dam. Total number of pounds and number of fish stocked from October 2018 through March 2020. All reported fish are catchable size.*

Fiscal Year	Number of Pounds	Number of Fish	Fish per Pound	Put & Take Zone	Catch & Release Zone
2018-2019	16,600	49,800	3.00	75%	25%
2019-2020	15,800	49,870	3.16	77%	23%

Table D3. *Stocking information for the Trout Incubator Program, 2007 through 2019, shows number of eggs incubated by year, estimated number of fry released, and percentage of fry released into both the Put & Take and Catch & Release zone. A question mark indicates no information is avaiable. From 2007 through 2012 rainbow trout eggs were hatched in streamside incubators, and from 2012 through 2019 were hatched in the incubator building.*

Fiscal Year	**Eggs Incubated (#)**	**Fry Released (Est #)**
2006-2007	166,000	87,500
2007-2008	150,000	?
2008-2009	300,000	?
2009-2010	300,000	?
2010-2011	150,000	?
2011-2012	150,000	?
2012-2013	482,000	?
2013-2014	300,000	?
2014-2015	300,000	?
2015-2016	304,000	90,000[a]
2016-2017	324,000	210,000
2017-2018	370,000	214,000
2018-2019	232,000	149,000

[a] - actual release higer, estimate provided is from only one of three incubation runs in the fiscal year

APPENDIX E

Water Year Information: 2007-2019

Table E1. *Annual Runoff in the Kings River watershed and percentage of average per water year. Water year runs from (October 1 through September 30).*

Year	Annual Runoff (Acre Feet)	Water Year (%)
2007	679,000	40
2008	1,216,000	72
2009	1,348,000	80
2010	2,062,000	122
2011	3,318,000	196
2012	826,000	49
2013	691,000	41
2014	537,000	32
2015	361,000	21
2016	1,253,000	74
2017	4,096,000	242
2018	1,275,000	75
2019	2,177,000	171