NORMANDEAU
environmental consultants

Memorandum

DATE: 24 February 2014
TO: Chris Lee and Rich Marovich, Solano County Water Agency
FROM: Tim Salamunovich, Normandeau Associates
RE: Results of October 2013 lower Putah Creek fish surveys

Normandeau Associates (formerly Thomas R. Payne & Associates) has been sampling the fish fauna of lower Putah Creek using tote barge electrofishing since August 1991. Dr. Peter Moyle of University of California at Davis (UCD) has been sampling the creek near campus using a combination of boat/backpack electrofishing, seining, and gill netting with his fisheries classes annually since 1978. Since the May 2000 Putah Creek Water Accord, Normandeau has been surveying multiple sites along the creek each October as part of an annual fish monitoring program under the Lower Putah Creek Coordinating Committee. A database containing all the raw data (individual fish lengths and weight data by site and survey date) for the entire period of record is regularly updated and managed by SCWA. The data through 2008 was treated in a recent scientific publication (Kiernan et al. 2012). This paper demonstrated the recovery of native fishes in the upper 12.5 miles of the creek (upstream of Pedrick Road [County Road 98]) following the native fish rearing and spawning flows instituted under the Water Accord. In October 2014 Normandeau sampled nine sites along the lower creek between Putah Diversion Dam (PDD) and Mace Boulevard (County Road 104; Figure 1). Due to access issues, the PDD site (the normal upstream site) was not sampled in 2014; instead an alternate site (the Morales site), located 0.65 miles downstream was sampled. Two additional sites near the UCD campus were sampled on 19 October 2013 by Dr. Moyle's class (Figure 1) and the results were generously provided for review. This memo report will present the results of these two most recent sampling efforts.

The objective of the Fall 2013 electrofishing survey was to determine the distribution and relative abundance of fish populations in lower Putah Creek between Putah Diversion Dam and Mace Boulevard [Yolo County Road 104] (Figure 1). Normandeau conducted sampling at nine locations on 15-17 October 2012 using a Smith-Root gas powered generator and pulsator (model 2.5 GPP) operated out of a small pram. Two biologists wading alongside the pram operated two six-foot long electrofishing probes to attract and stun fish. Two additional biologists netted and captured stunned fish and transferred them to several five-gallon aeration buckets located in the front of the pram. A fifth person rowed or pulled the boat and was primarily responsible for shutting off the electric current in the event of a mishap. Sampling effort was emphasized along the margins of the creek around instream cover and overhead vegetation, but additional effort was still allocated to open water portions of the creek. Total effort expended at each site was made approximately equal by a combination of measurements of stream area and shocking seconds. All stunned fish were netted and held in buckets equipped with small bait-bucket aerators and captured fish were periodically transferred to a live

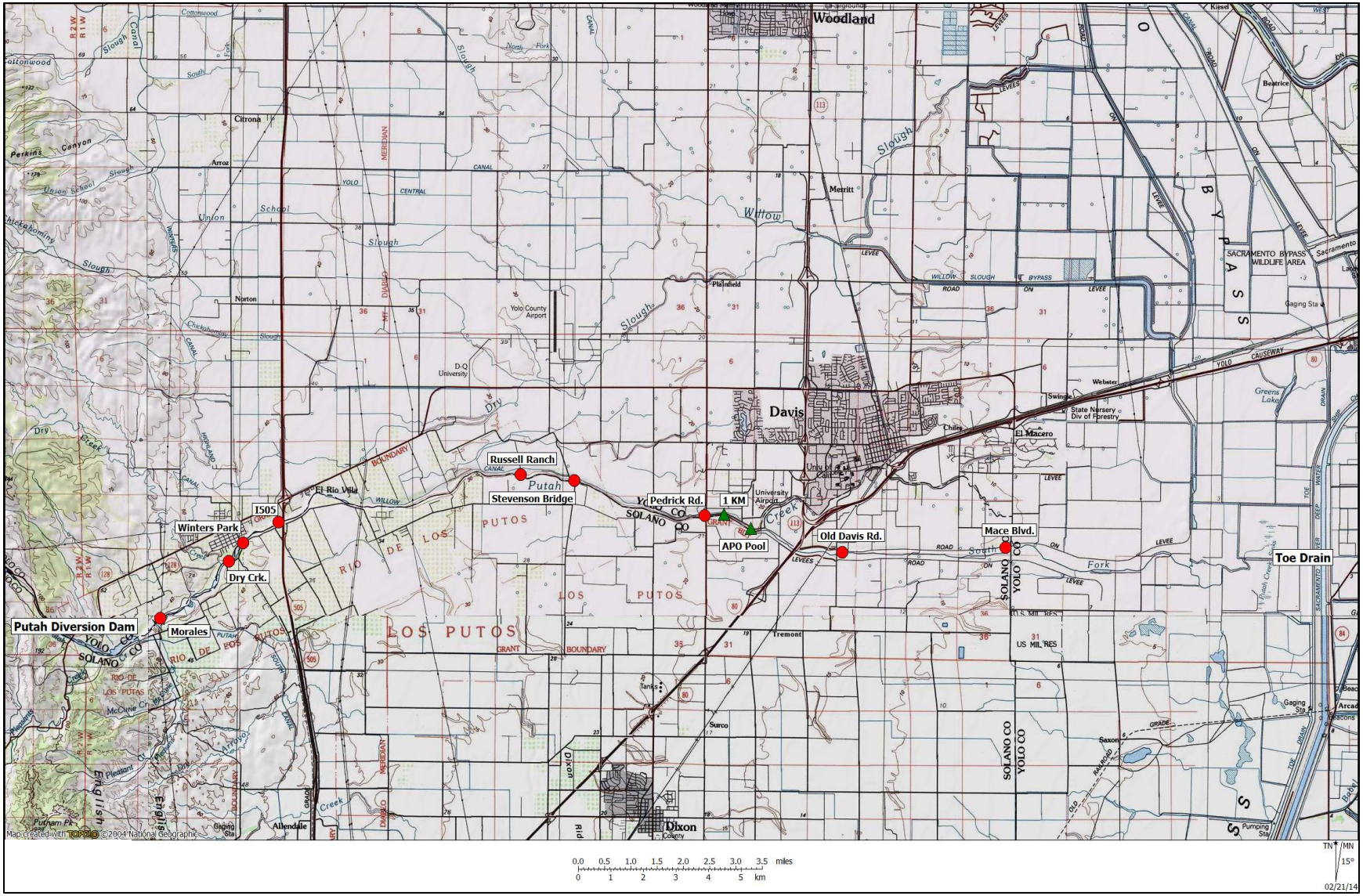

Figure 1. Map showing the nine Normandeau sample sites (red circles) and two UCD sample sites (green triangles) surveyed along lower Putah Creek in October 2013.

cart until the completion of sampling, at which time the fish were identified and enumerated. Most fish were measured (to either fork length (FL) or total length (TL) and a sub-sample of these was also weighed to determine condition factors (length-weight ratios) prior to release. At the Old Davis Road site, western Mosquitofish (*Gambusia affinis*) were counted, but not measured.

Two additional sites (the Alpha Phi Omega [APO] pool and the 1 Kilometer sites) were sampled by students of Dr. Peter Moyle's Wildlife, Fish, & Conservation Biology class on 19 October 2013 (Figure 1). This UCD fish sampling used a variety of capture gear including seines (10 meter and 100 meter), gillnets, and backpack electrofishers, and an electrofishing boat (equipped with a 5.0 GPP). All fish were identified, enumerated, and most were measured to standard length (SL) or total length and released. When large numbers of a species were captured, a sub-sample was measured.

The year prior to the sampling was classified as a dry water year for the Sacramento basin according the Sacramento Valley 40-30-30 Hydrologic Classification Index (from DWR California Data Exchange Center). Six of the last seven Water Years in the Sacramento Valley have been classified as below normal or dry. The flows in lower Putah Creek (as measured at the Putah Diversion Dam release) during the period of fish spawning and rearing for the year prior to sampling is shown in Figure 2.

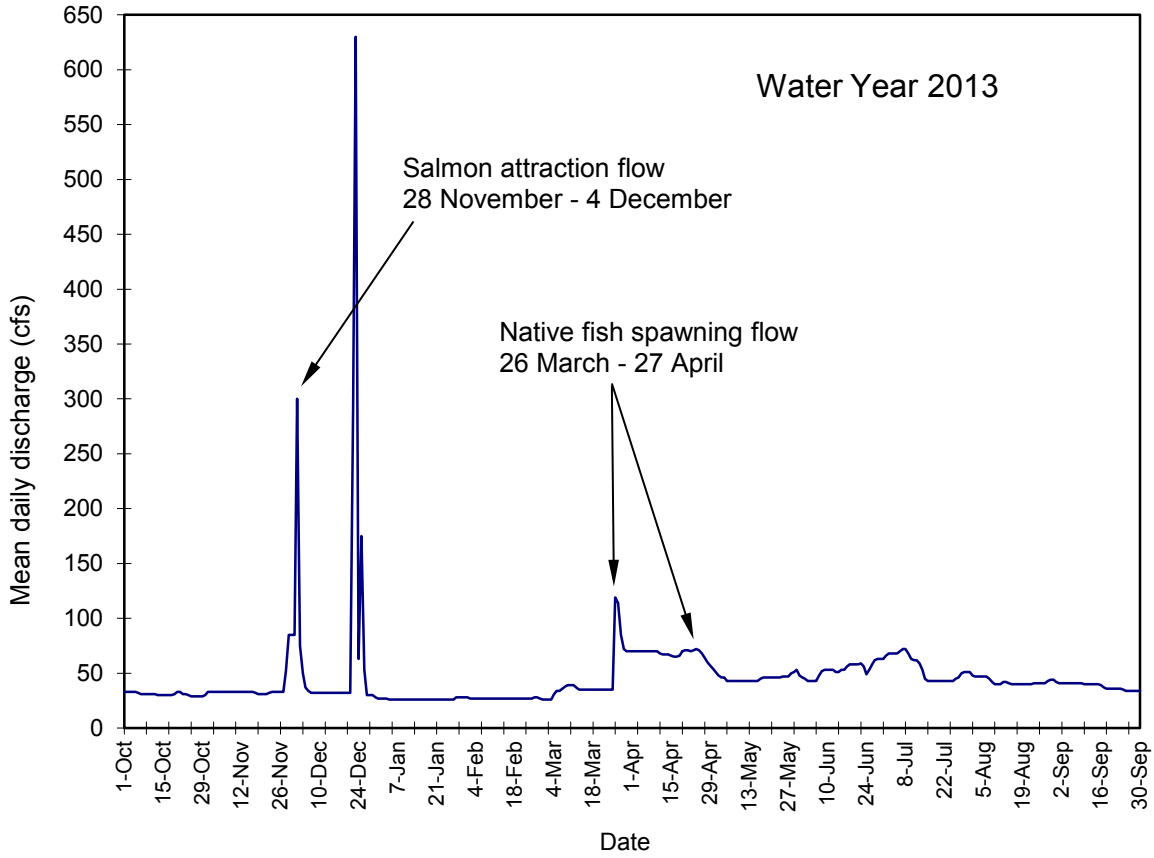

Figure 2. Mean daily discharge released into lower Putah Creek at the Putah Diversion Dam during the 2013 Water Year.

There were no extended periods of high flows during the 2012 water year (Table 1). The maximum flow for the water year immediately prior to sampling was 630 cfs cubic feet per second (cfs) and was the result of short-term run-off from a late December 2012 storm event that dropped 3.65 inches of rain over a three-day period. Despite the dry water year, the mean dam release to the lower creek for the period was 45.6 cfs.

Table 1. Number of days that mean daily releases from Putah Diversion Dam exceeded certain values during the 2012 water year (1 October 2012–30 September 2013) immediately prior to the October 2013 surveys. Data from USBR Mid-Pacific Region, Central Valley Operations Website.

Exceedance (cubic feet per second)	Number of Days
≥ 500 cfs	1
≥ 300 cfs	2
≥ 250 cfs	3
≥ 200 cfs	3
≥ 150 cfs	4
≥ 100 cfs	6
≥ 50 cfs	92
≥ 25 cfs	365

As specified in the Water Accord, flows in Putah Creek at Interstate 80 Bridge near Davis are monitored and dam releases to lower creek adjusted to maintain minimum flows of at least 5 cfs (or higher) throughout the year (Table 2). This flow requirement ensures maintenance of a live stream throughout the lower basin even during dry and critically dry water years. In addition, the Accord includes supplemental flow releases into the lower basin to attract anadromous salmonids in the fall and to promote native fish spawning in the spring (Figure 2).

Table 2. Mean daily flow requirements for Putah Creek at Interstate 80.

Month	Minimum Flow Requirement (cfs)
October	5
November	10
December	10
January	15
February	15
March	25
April	30
May	20
June	15
July	15
August	10
September	5

Stream flow in the lower basin during the October 2012 fish surveys survey varied by site and ranged from 30 cfs at the Putah Diversion Dam to less than 13 cfs at the sites downstream of the I-80 Bridge (Table 3).

Table 3. River mile location, sample date, survey time, stream flow, water temperature, conductivity, and salinity at time of survey for the eleven lower Putah Creek study sites during the October 2013 fish monitoring surveys. Putah Divesrion Dam (not sampled) is at RM 22.6. River mile notation is based upon USBR convention where RM 0.0 is point where creek enters the Yolo Bypass.

Site	River Mile	Date	Time	Flow [1/] (cfs)	Temp (°C)	DO (mg/L)	Cond µS/cm	Salinity ppt
Morales Orchard	22.0	10/17/13	1600	34.0	14.4	9.1	276	0.2
Dry Creek confluence	20.3	10/17/12	1300	35.9	13.9	10.5	277	0.2
Winters Park (Car Bridge)	19.7	10/17/12	0930	35.1	12.8	9.2	270	0.2
Interstate 505 Bridge (I505)	18.9	10/16/12	1715	33.7	14.4	9.7	280	0.2
Russell Ranch	13.7	10/16/12	1430	11.7	14.9	10.0	295	0.2
Stevenson Road Bridge	12.8	10/16/12	1130	12.1	14.0	8.2	294	0.2
Pedrick Road Bridge	9.9	10/16/12	0800	15.7	13.1	8.3	291	0.2
1 Kilometer Site (1 KM)	9.4	10/19/12	1100	17.5	---	---	---	---
Alpha Phi Omega (APO) Pool	9.1	10/19/12	1100	17.5	15.5	9.6	397	---
Old Davis Road Bridge	7.2	10/15/12	1400	7.9	17.3	10.3	462	0.3
Mace Boulevard Bridge	3.8	10/15/12	1000	7.9	14.2	5.9	515	0.3

1/ Flow data from Solano County Water Agency

Water temperatures measured during the October survey varied by site as a function of both the time of day and the distance downstream of the Putah Diversion Dam release point (Table 2). Water conductivity (a measure of total dissolved solids) and salinity tended to increase in relation to the distance downstream of the Putah Diversion Dam. Except for the most downstream Mace Boulevard site, dissolved oxygen levels were relatively high and typically exceeded 8 mg/L.

The October 2013 fish surveys of lower Putah Creek captured a total of 4,040 fish representing 20 species (Table 4). Of the total number captured, 78.9 percent (3,187 fish from 8 species) were natives, while 21.1 percent (853 fish from 12 species) were non-native, or exotic fishes. The overall distribution of fishes from the October 2013 survey remains similar to recent surveys and continues to show that lower Putah Creek supports a highly diverse fish fauna. The results also show that, despite two consecutive dry water years and lack of extended periods of high flow, native fish continue to dominate the 13.2 miles of the lower basin between the Putah Diversion dam and the 1 KM site near Davis (Table 4; Figures 3 and 4).

The catch data show that native fish dominated the catch in the upper 13.2 miles of the study area between the Putah Diversion Dam and 1 KM sites (Table 4). In fact, no non-native fish were captured in the upper 9.0 miles of the study area and native fish made

Table 4. Capture data for the October 2013 fish monitoring surveys on lower Putah Creek. The 1KM and APO sites were sampled by UCD on 19 October; the remaining nine sites were sampled by Normandeau Associates on 15-17 October.

Fish	MOR	DRY	WPK	I505	RR	STEVE	PED	1KM	APO	OLD	MACE	Total
Native Fishes												
Hitch									1 (133 SL)			1
Sacramento pikeminnow	5 (108-206 FL)	56 (49-244 FL)	21 (43-188 FL)	14 (62-154 FL)	258 (45-264 FL)	165 (49-460 FL)	592 (49-318 FL)	187 (46-190 SL)	3 (152-440 SL)		10 (99-253 FL)	1,311
Sacramento sucker	1 (136 FL)	196 (43-210 FL)	92 (40-281 FL)	83 (40-256 FL)	52 (76-272 FL)	32 (67-401 FL)	272 (75-272 FL)	23 (58-233 SL)	27 (230-447 SL)	1 (272 FL)	5 (175-343 FL)	784
Rainbow trout	18 (105-263 FL)	19 (109-285 FL)	8 (136-295 FL)	4 (102-136 FL)	1 (124 FL)							50
Threespine stickleback	6 (31-53 TL)	1 (46 TL)	49 (23-62 TL)	19 (25-47 TL)								75
Prickly sculpin	78 (41-90 TL)	14 (54-101 TL)	49 (50-155 TL)	19 (55-101 TL)	136 (37-120 TL)	73 (40-85 TL)	119 (44-106 TL)			1 (63 TL)	4 (59-65 TL)	493
Riffle sculpin	63 (40-112 TL)	13 (49-99 TL)	73 (40-99 TL)									149
Unid'd sculpin								19 (33-86 SL)	1 (45 SL)			20
Tule perch		103 (58-128 FL)	37 (62-118 FL)	51 (56-102 FL)	56 (74-123 FL)	36 (74-128 FL)	13 (87-110 FL)	5 (59-95 SL)	3 (94-100 SL)			304
Exotic Fishes												
Red shiner											6 (38-63 FL)	6
Goldfish							6 (129-158 FL)					6
Common Carp									4 (230-275 SL)		2 (266-270 FL)	6
White catfish											2 (48-59 FL)	2
Inland silverside							1 (66 FL)	12 (21-53 TL)	17 (43-80 SL)	60 (35-103 FL)	38 (48-88 FL)	128
Western mosquitofish								32 (12-41 TL)	31 (17-40 SL)	18 not measured	5 (17-41 SL)	86
Bluegill									57 (22-135 SL)	12 (52-165 FL)	4 (61-119 FL)	73
Redear sunfish											1 (158 FL)	1
Warmouth											2 (65-79 FL)	2
Green sunfish					2 (86-91 FL)			22 (25-132 SL)	17 (25-84 SL)	6 (42-117 FL)	20 (55-108 FL)	67
Unid'd sunfish								2 (24-44 TL)	2 (34-38 TL)			4
Largemouth bass					10 (67-139 FL)	5 (117-229 FL)	10 (78-151 FL)	48 (38-139 SL)	54 (35-430 SL)	138 (62-468 FL)	109 (66-370 FL)	374
Bigscale logperch						5 (86-95 TL)	7 (85-111 TL)	9 (31-101 SL)	54 (61-95 SL)	14 (83-123 TL)	9 (89-120 TL)	98
Total # Individuals	171	402	329	190	515	316	1,020	359	271	250	217	4,040
# native fish	171	402	329	190	503	306	996	234	35	2	19	3,187
# exotic fish	0	0	0	0	12	10	24	125	236	248	198	853
Total # species	6	7	7	6	7	6	8	8	11	8	14	20
# native species [1/]	6	7	7	6	5	4	4	3	4	2	3	8
# exotic species[2/]	0	0	0	0	2	2	4	5	7	6	11	12
Shannon's Diversity (ln)[3/]	1.214	1.361	1.769	1.449	1.281	1.288	1.091	1.602	2.008	1.301	1.719	2.076
Eveness (H'/Hmax)	0.677	0.699	0.909	0.809	0.658	0.719	0.525	0.729	0.808	0.626	0.651	0.693

[1/] unidentified sculpin, probably prickly sculpin

[2/] unidentified sunfish not counted as separate species, but distributed between bluegill and green sunfish

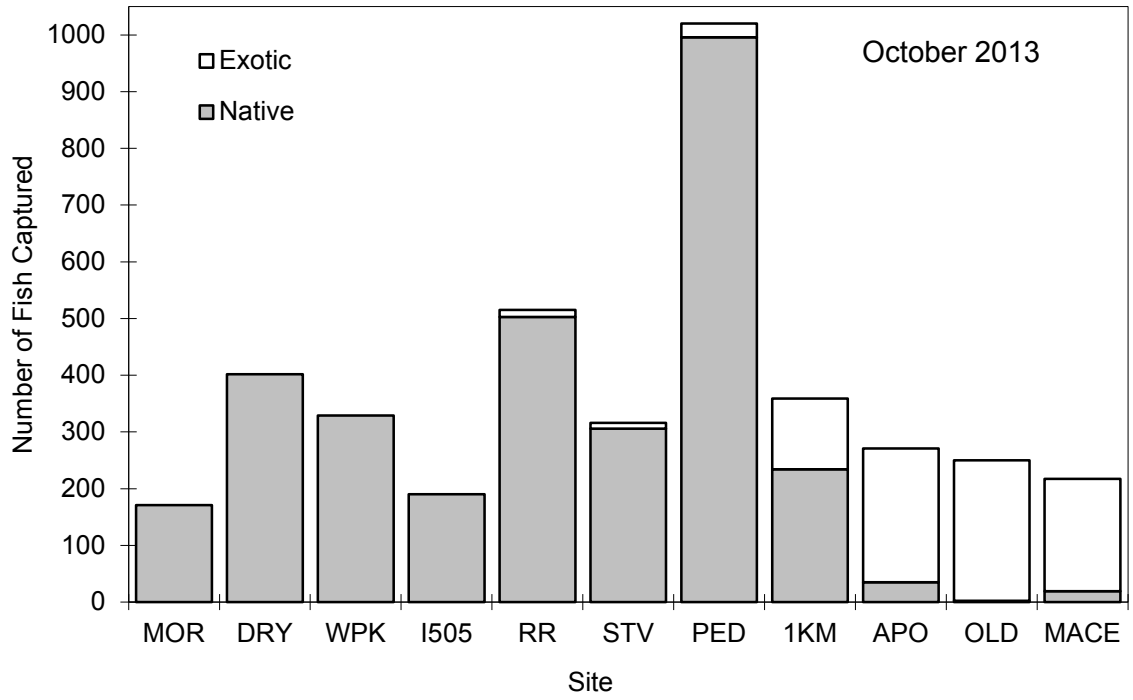

Figure 3. Number of native and exotic fish captured at each of the lower Putah Creek study sites during the October 2013 fish surveys.

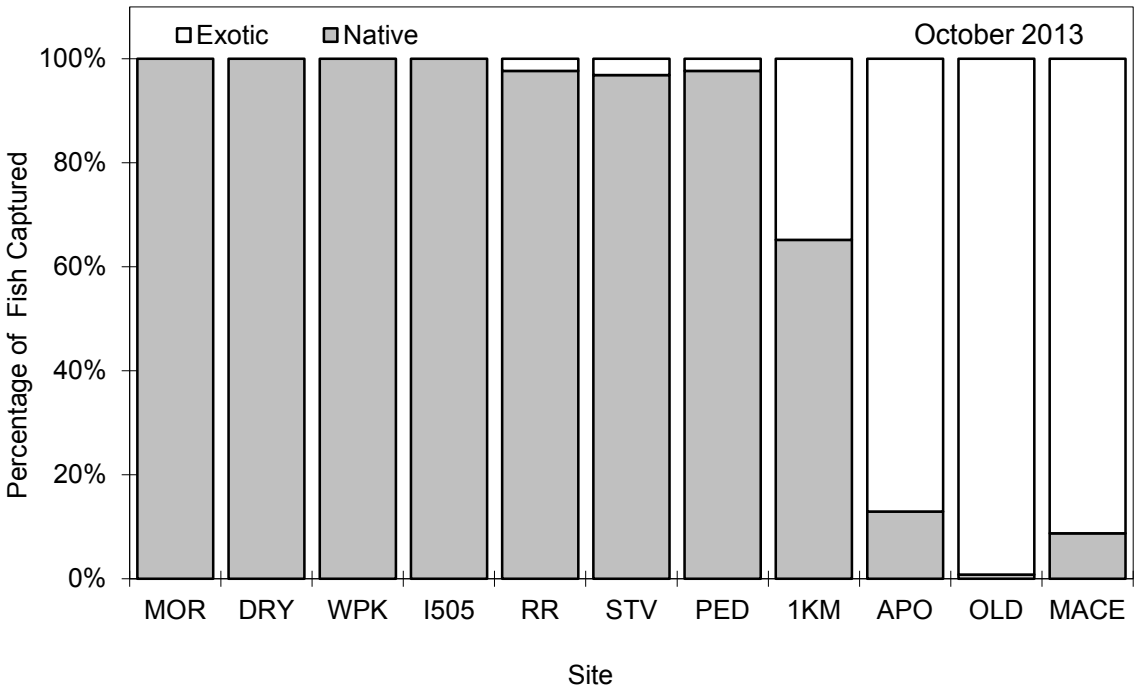

Figure 4. Percentage of native and exotic fish captured at each of the lower Putah Creek study sites during the October 2013 fish surveys.

up 98.4 percent of the total catch at the seven study sites located in the upper 12.7 miles of the study area upstream of the Pedrick Road sites (Figure 4). At the 1 KM Site, which is located about 0.5 miles downstream of Pedrick Road, non-native fish abundance had increased to almost 35 percent of the total catch and the that fraction increased again just downstream at the APO Pool site where non-native now dominated the local fish populations and contributed 87 percent of the total catch. At the two remaining downstream sites (Old Davis Road and Mace Boulevard) non-native made up over 99 percent and 91 percent of the total catches, respectively (Figure 4).

Of the native species captured during the October survey, some had very limited distributions. Hitch (Lavinia exilicauda), a high-temperature tolerant native minnow, were only noted at one site, the APO Pool. Threespine stickleback (*Gasterosteus aculeatus*) and riffle sculpin (*Cottus gulosus*) were noted only as far downstream as the I-505 site (Table 4). Rainbow trout (*Oncorhynchus mykiss*) had a slightly wider distribution and were captured at all five sites between the PDD and Russell Ranch. The capture of rainbow trout at the Russell Ranch site represents the first capture of any salmonid at this site over twelve sampling events conducted over the last 13 years. Upstream habitat improvements (e.g. removal of the Winters Percolation Dam and the Winters Park channel restoration) may be aiding the widening distribution of coldwater dependent salmonids, through the downstream extension of cool water. Future monitoring may provide additional evidence about whether trout are able to become part of the regular fish fauna found at Russell Ranch and other sites downstream.

Other native species exhibited a much wider range of distribution in the lower basin (Table 4). Sacramento suckers (*Catostomus occidentalis*) were captured at all the sites between the diversion dam and Mace Boulevard. Sacramento pikeminnow (*Ptychocheilus grandis*) were captured at ten of the eleven survey sites in 2013, while tule perch (*Hysterocarpus traskii*) were captured at eight sites. Pikeminnow and sucker were the most abundant fish during the 2013 survey, and comprised 32.5 percent and 19.4 percent of the total catch, respectively (Table 4). Despite their wide distribution throughout the lower basin, both pikeminnow and suckers were most abundant between the Dry Creek and Pedrick Road.

The distribution of exotic fishes also varied by species (Table 4). As was mentioned earlier, no exotic species were capture upstream of the Russell Ranch site (Table 4). Red shiner (*Cyprinella lutrensis*), goldfish (*Carassius auratus*), redear sunfish (*Lepomis microlophus*) and warmouth (*L. gulosus*) were limited to only one location in the lower basin. Largemouth bass (*Micropterus salmoides*) was widely distributed and was captured at the lowermost seven sites along Putah Creek. The most abundant non-native fish species during the 2013 surveys was largemouth bass, which made up just over nine percent of the total catch (Table 4).

One noteworthy pattern noted in the 2012 sampling was the continued decline in the exotic "panfish" populations that were first noted in the 2010 surveys. This group is comprised of the smaller sunfish of the genus Lepomis and includes bluegill (*Lepomis macrochirus*), green sunfish (*L. cyanellus*), redear sunfish, warmouth (*L. gulosus*),

pumpkinseed (*L. gibbossus*) and various hybrids forms. Prior to 2010, green sunfish and bluegills were among the most common species of fish found in lower Putah creek. In the six fall surveys conducted between 2003-2008 "lepomids" made up 33.8 percent of the total captures. In 2010, "lepomids" had declined to only 6.8 percent of the total fish captured, and in both 2012 and 2013 they comprised only 3 to 4 percent of the total fish captures. The scarcity of "lepomids" in 2012 and 2013 is especially surprising since both years were dry water years with few periods of high flow. These non-native sunfish species usually thrive during these low and warm water conditions. Future surveys may show if these exotic sunfish abundances rebound to former levels, or perhaps this suite of species is in fact finding conditions in lower Putah Creek no longer suitable to sustain abundant population levels.

Despite the recent declines in the "lepomid" sunfish populations in lower Putah Creek, the larger centrarchids, such as the "micopterid" basses or black bass (especially largemouth bass) still remain abundant, especially in the lower 14 miles of the creek (Table 4). In the 2003-2008 surveys, bass (i.e., largemouth, smallmouth, and spotted bass) made up 8.2 percent of the total fish captured. In the 2010 and 2012 surveys, they made up 11.2 percent and 11.8 percent of the captures in those years. The 2013 abundance was intermediate to these levels. So while the sunfish species have exhibited a decline in recent years, the basses have remained a dominant fish, especially in the downstream survey areas.

The 2013 survey included the Winters Park site, which represents a relatively new site along lower Putah Creek that has been sampled only twice, 2012 and 2013. In November 2011, a channel realignment project (Winters Park Project) was completed along a 3,700 foot-long section of Putah Creek. This project was designed to restore natural channel form and function, enhance habitat of native species and improve public access in a reach that had been mined extensively for gravel and otherwise enlarged, straightened and dammed for flood conveyance and seasonal water storage. This project included removing a long-standing low flow barrier (Winters Percolation Dam), reconfiguring the creek channel to a narrower and shallower meandering form, restoring the functional floodplain, and restoring native plant species along the riparian corridor. Three existing riffles were augmented and 14 new riffles were created at 200 foot intervals by importing 2,000 tons of salmon spawning gravel mix (Rich Marovich, personal communication). It was anticipated that this channel realignment project would eliminate the extensive areas of large deep pool habitat that acted as a heat sink and harbored large predatory non-native basses, and instead create hydraulically diverse and cooler water habitat that would benefit native fish, especially salmonids. Fish salvage and relocation conducted through the project area prior to construction included only one rainbow trout in this section of Putah Creek (Peter Moyle, personal communication).

Twenty rainbow trout were captured in October 2012 and another eight rainbow trout were captured in October 2013 (Table 4). During both these surveys, most of the trout were captured in the turbulent water immediately below the boulder weirs or in a short shallow riffle near the upstream end of the site. In any case, rainbow trout appear to be using the recently restored channel area and appear to be present in larger numbers

than were present prior to the channel realignment. We hope to continue to monitor fish distribution and abundance in the Winters Park area of Putah Creek as part of future surveys. On-going bridge construction is scheduled to occur over the next four to five years and may potentially limit access and sampling opportunities.

In conclusion, despite continuing dry water years and limited periods of extended high flow, the native fish populations continue to thrive in the thirteen miles of Putah Creek between the Putah Diversion Dam to areas downstream of Pedrick Road. The 2014 water year is currently predicted to be one of the driest on record. Continued fall fish monitoring should indicate how the fish populations respond to the on-going drought conditions and the continuing benefits of the Settlement Agreement flow regime.

Literature Cited

Kiernan, J.D., P.B. Moyle, and P.K. Crain. 2012. Restoring native fish assemblages to a regulated California stream using the natural flow regime concept. Ecological Applications 22:1472-1482.