Memorandum

DATE: 4 February 2015
TO: Rich Marovich and Chris Lee, Solano County Water Agency
FROM: Tim Salamunovich, Normandeau Associates
RE: Results of October 2014 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 aegis of 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 19 miles of the lower creek between Putah Diversion Dam (PDD) and Mace Boulevard (County Road 104; Figure 1). Two additional sites near the UCD campus were sampled on 8 November 2014 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 2014 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 21-23 October 2014 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

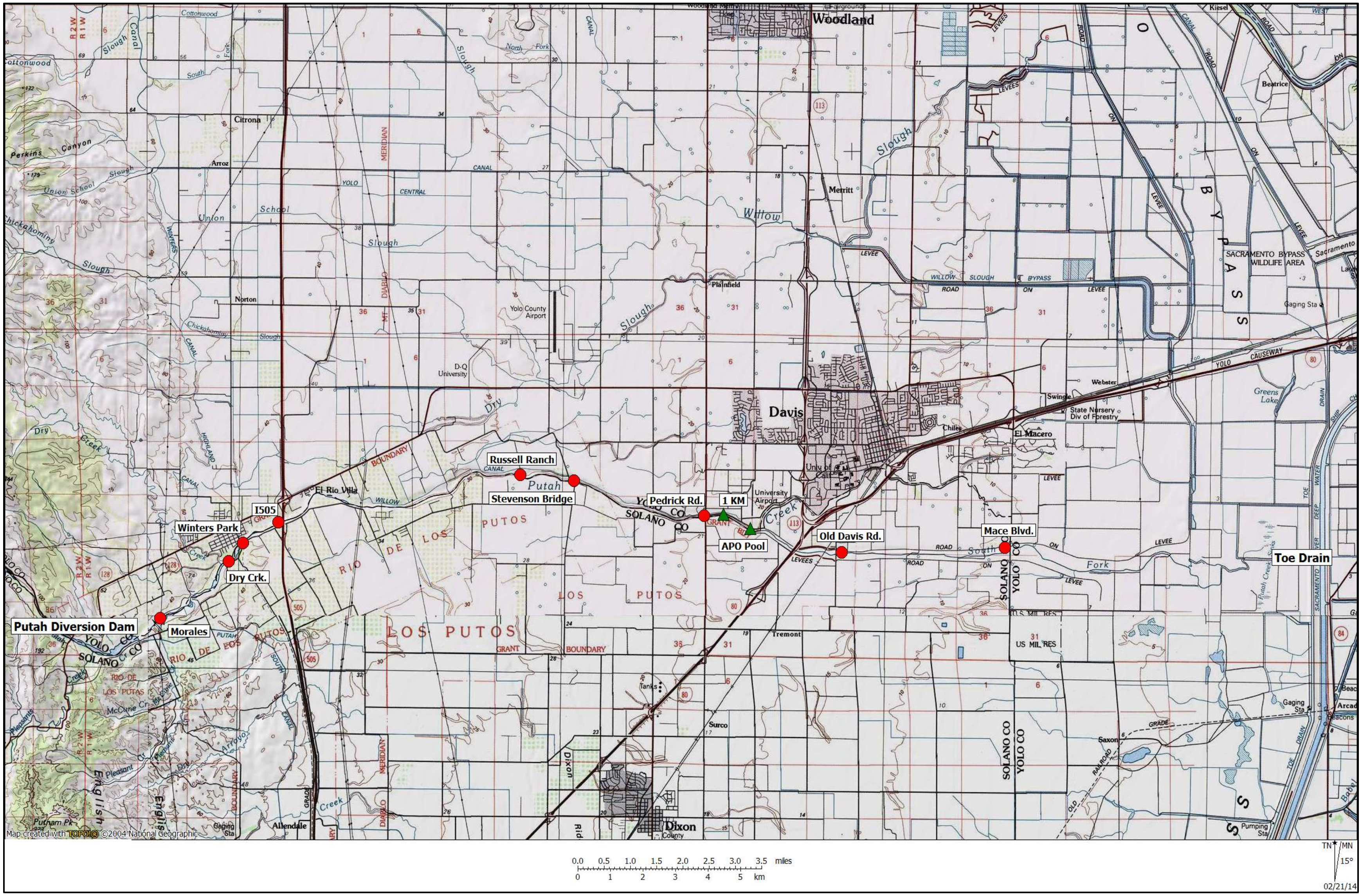

Figure 1. Map showing the nine Normandeau sample sites (red circles) and two UCD sample sites (green triangles) surveyed along lower Putah Creek in October 2014.

cart until the completion of sampling, at which time the fish were identified and enumerated. 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 Putah Diversion Dam Site, only a sub-sample of the catch of threespine stickleback (*Gasterosteus aculeatus*) was 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 8 November 2014 (Figure 1). This UCD fish sampling used a variety of capture gear including beach seines, gillnets, clover traps, hook and line, and a boat shocker (equipped with a 5.0 GPP) at the APO Pool Site; and backpack electrofishers and hook and line at the 1 Kilometer Site. All fish were identified, enumerated, and most were measured to standard length (SL) or total length and released.

The year prior to the sampling was classified as a critical water year for the Sacramento basin according the Sacramento Valley 40-30-30 Hydrologic Classification Index (from DWR California Data Exchange Center). Seven of the last eight Water Years in the Sacramento Valley have been classified as below normal, dry, or critical. 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.

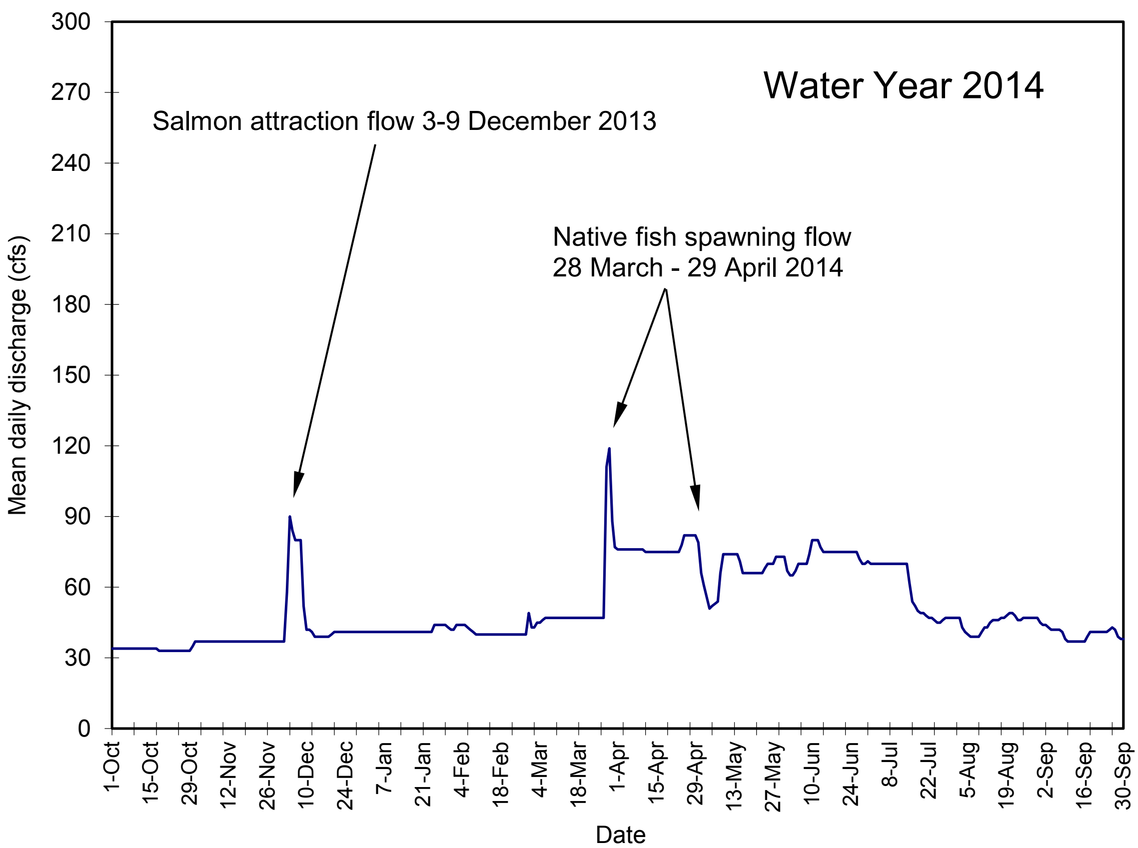

Figure 2. Mean daily discharge released into lower Putah Creek at the Putah Diversion Dam during the 2014 Water Year.

There were no extended periods of high flows during the 2014 water year (Table 1). The maximum flow for the water year immediately prior to sampling was 119 cfs cubic feet per second (cfs) and was the result of late March managed flow releases into the lower creek to accommodate native fish spawning. Despite the dry water year, the mean dam release to the lower creek for the 2014 Water Year was 51.3 cfs, and the dam release flow never fell below 33 cfs during the period.

Table 1. Number of days that mean daily releases from Putah Diversion Dam exceeded certain values during the 2014 water year (1 October 2013–30 September 2014) immediately prior to the October 2014 surveys. Data from USBR Mid-Pacific Region, Central Valley Operations Website.

Exceedance (cubic feet per second)	Number of Days
≥ 500 cfs	0
≥ 300 cfs	0
≥ 250 cfs	0
≥ 200 cfs	0
≥ 150 cfs	0
≥ 100 cfs	2
≥ 50 cfs	120
≥ 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 15.5 miles of 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 2014 fish surveys survey varied by site and ranged from 39 cfs at the Putah Diversion Dam to 6 cfs at the sites downstream of the I-80 Bridge (Table 3). Flows in the lower basin at the two UCD sample areas were about 16 cfs during the early November surveys.

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 2014 fish monitoring surveys. 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
Putah Diversion Dam	22.6	10/23/14	1510	39.4	14.9	9.5	294	0.2
Dry Creek confluence	20.3	10/23/14	1100	29.7	14.3	8.6	294	0.2
Winters Park (Car Bridge)	19.7	10/22/14	1735	29.2	15.4	10.0	295	0.2
		10/23/14	0855	29.3	14.7	9.4	294	0.2
Interstate 505 Bridge (I505)	18.9	10/22/14	1620	29.5	15.8	10.4	295	0.2
Russell Ranch	13.7	10/22/14	1300	12.2	15.3	9.7	299	0.2
Stevenson Road Bridge	12.8	10/22/14	1005	12.1	14.2	8.3	293	0.2
Pedrick Road Bridge	9.9	10/21/14	1630	12.5	16.4	9.2	312	0.2
1 Kilometer Site (1 KM)	9.4	11/8/14	1100	15.6	---	---	---	---
Alpha Phi Omega (APO) Pool	9.1	11/8/14	1100	15.6	---	---	---	---
Old Davis Road Bridge	7.2	10/21/14	1310	5.9	18.8	9.47	538	0.3
Mace Boulevard Bridge	3.8	10/21/14	1017	5.9	15.0	7.2	418	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 exceeded 8 mg/L at the remaining eight sites sampled in late October. No water quality data was recorded during the UC Davis surveys in early November.

The late October/early November 2014 fish surveys of eleven lower Putah Creek sites captured a total of 2,915 fish representing 23 species (Table 4). Sacramento pikeminnow (*Ptychocheilus grandis*) was the most abundant species, making up about 34 percent of the total catch. The next most common fishes among the catch were largemouth bass (*Micropterus salmoides*) at 12%, tule perch (*Hysterocarpus traskii*) at 10%, Sacramento sucker (*Catostomus occidentalis*) at 10%, and prickly sculpin (*Cottus asper*) at about 8% of the total catch. None of the remaining eighteen species made up more than 5% of the total catch.

Table 4. Capture data for the October/November 2014 fish monitoring surveys on lower Putah Creek.

Fish	PDD	DRY	WPK	I505	RR	STEVE	PED	1KM	APO	OLD	MACE	Total
Native Fishes												
Sacramento pikeminnow	11 (121-211 FL)	74 (42-179 FL)	2 (140-145 FL)	10 (92-153 FL)	248 (51-225 FL)	179 (41-530 FL)	305 (78-321 FL)	151 (46-302 SL)	4 (143-200 SL)		4 (180-327 FL)	988
Sacramento sucker	5 (150-257 FL)	105 (41-198 FL)	10 (57-182 FL)	36 (39-210 FL)	25 (91-255 FL)	3 (83-406 FL)	69 (116-330 FL)	11 (115-200 SL)	21 (287-510 SL)		5 (177-200 FL)	290
Rainbow trout	80 (106-463 FL)	24 (98-182 FL)	9 (123-273 FL)	5 (108-165 FL)	2 (123-130 FL)							120
Threespine stickleback	130 (19-62 TL)	3 (42-56 TL)	2 (54-61 TL)	3 (45-54 TL)				1 (46 SL)				139
Prickly sculpin	15 (59-101 TL)	15 (46-107 TL)	31 (49-105 TL)	2 (114-122 TL)	32 (55-90 TL)	22 (53-111 TL)	61 (48-98 TL)	45 (38-61 SL)	1 (50 TL)	1 (65 TL)	2 (93-109 TL)	227
Riffle sculpin	40 (55-124 TL)	17 (65-101 TL)	53 (52-112 TL)		6 (55-87 TL)	4 (56-87 TL)	13 (49-89 TL)					133
Tule perch		80 (58-120 FL)		91 (62-111 FL)	67 (80-127 FL)	34 (65-122 FL)	19 (89-131 FL)				2 (123-140 FL)	293
Pacific lamprey	2 (115-128 TL)	1 (120 TL)										3
Exotic Fishes												
Golden Shiner											6 (79-170 FL)	6
Red shiner											2 (36-41 FL)	2
Goldfish									3 (32-87 SL)	1 (160 FL)	2 (170-240 FL)	6
Common Carp									2 (620-775 SL)			2
White catfish										1 (170 FL)		1
Inland silverside					1 (35 FL)		11 (39-54 FL)		(43-80 SL)		61 (30-79 FL)	73
Western mosquitofish							6 (26-45 TL)	12 (14-42 TL)	35 (20-38 SL)	5 (23-42 TL)	12 (22-57 TL)	70
Bluegill								5 (86-123 SL)	52 (20-130 SL)	9 (106-152 FL)	32 (35-168 FL)	98
Redear sunfish									2 (155-180 SL)		1 (120 FL)	3
Green sunfish				6 (66-110 FL)		5 (38-144 FL)	3 (90-114 FL)	4 (54-100 SL)	12 (34-109 SL)	12 (81-176 FL)	13 (61-145 FL)	55
Smallmouth bass					1 (84 FL)			2 (87-88 SL)	2 (54-90 SL)	3 (92-136 FL)		8
Spotted bass										4 (104-129 FL)	3 (100-110 FL)	7
Largemouth bass	2 (132-155 FL)				4 (94-205 FL)	3 (158-270 FL)	16 (70-221 FL)	15 (67-220 SL)	60 (36-338 SL)	140 (55-424 FL)	100 (81-350 FL)	340
Striped bass										1 (239 FL)		1
Bigscale logperch						1 (113 TL)	11 (88-116 TL)	7 (76-107 SL)	10 (69-87 SL)	12 (76-120 TL)	9 (80-126 TL)	50
Total # Individuals	285	319	107	153	386	251	514	253	204	189	254	2,915
# native fish	283	319	107	147	380	242	467	208	26	1	13	2,193
# exotic fish	2	0	0	6	6	9	47	45	178	188	241	722
Total # species	8	8	6	7	9	8	10	10	12	11	15	23
# native species	7	8	6	6	6	5	5	4	3	1	4	8
# exotic species	1	0	0	1	3	3	5	6	9	10	11	15
Shannon's Diversity (ln)	1.411	1.608	1.285	1.200	1.142	0.997	1.402	1.366	1.861	1.101	1.856	2.225
Eveness (H'/Hmax)	0.679	0.773	0.717	0.617	0.520	0.479	0.609	0.593	0.749	0.459	0.685	0.710

Of the total fish captured in the fall 2014 survey, 75.2 percent (2,193 fish from 8 species) were natives, while 24.8 percent (722 fish from 15 species) were non-native, or exotic fishes. The overall distribution of fishes from the October 2014 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 three consecutive and worsening water years (WY2012 below normal; WY2013 dry; WY2014 critical) and the 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 site (Table 4). In fact, only two non-native fish were captured in the upper 3.0 miles of the study area and native fish made up 96.5 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 18 percent of the total catch and that fraction of exotic fish 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 95 percent of the total catches, respectively (Figure 4).

Of the native species captured during the October survey, some species, such as rainbow trout (*Oncorhynchus mykiss*) and pacific lamprey (*Entosphenus tridentatus*) were limited to the upper half of the study area (Table 4). The native pikeminnow, sucker, prickly sculpin, and tule perch were more widely distributed, and were found throughout the 19 mile study area between the Putah Diversion Dam and Mace Boulevard. Similar to last year, rainbow trout were captured at all five sites between the PDD and Russell Ranch. The capture of rainbow trout at the Russell Ranch site in both 2013 and 2014 are the only times any salmonid have been captured at this site located about nine below the PDD over thirteen sampling events conducted over the last 14 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.

The distribution of exotic fishes also varied by species (Table 4). Golden shiner (*Notemigonus crysoleucas*), red shiner (*Cyprinella lutrensis*), carp (*Cyprinus carpio*), white catfish (*Ameiurus catus*) and striped bass (*Morone saxatilis*) were limited to single locations in the lower basin. Largemouth bass (*Micropterus salmoides*) and green sunfish (*Lepomis cyanellus*) were widely distributed in the late Fall 2014 and were captured at eight and seven of the sites, respectively. While largemouth bass had a relatively wide distribution, their highest densities occurred along the lwer 5.5 miles of the survey area, at the APO pool and downstream (Table 4).

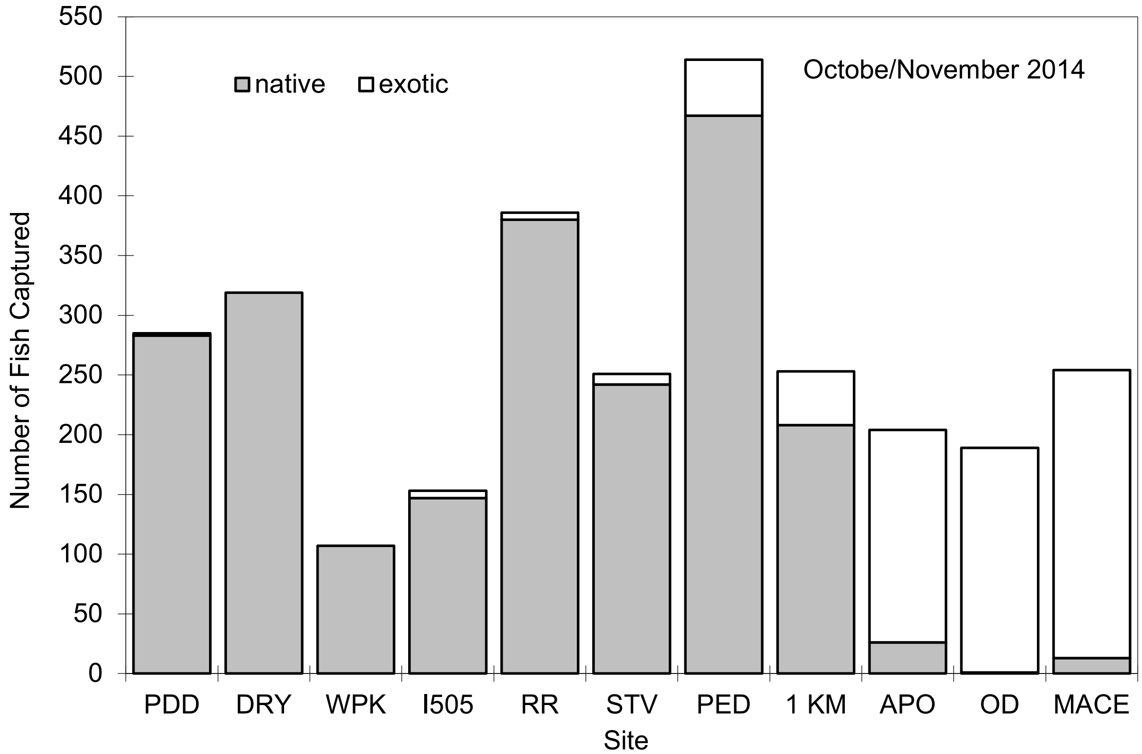

Figure 3. Number of native and exotic fish captured at each of the lower Putah Creek study sites during the late October and early November 2014 fish surveys.

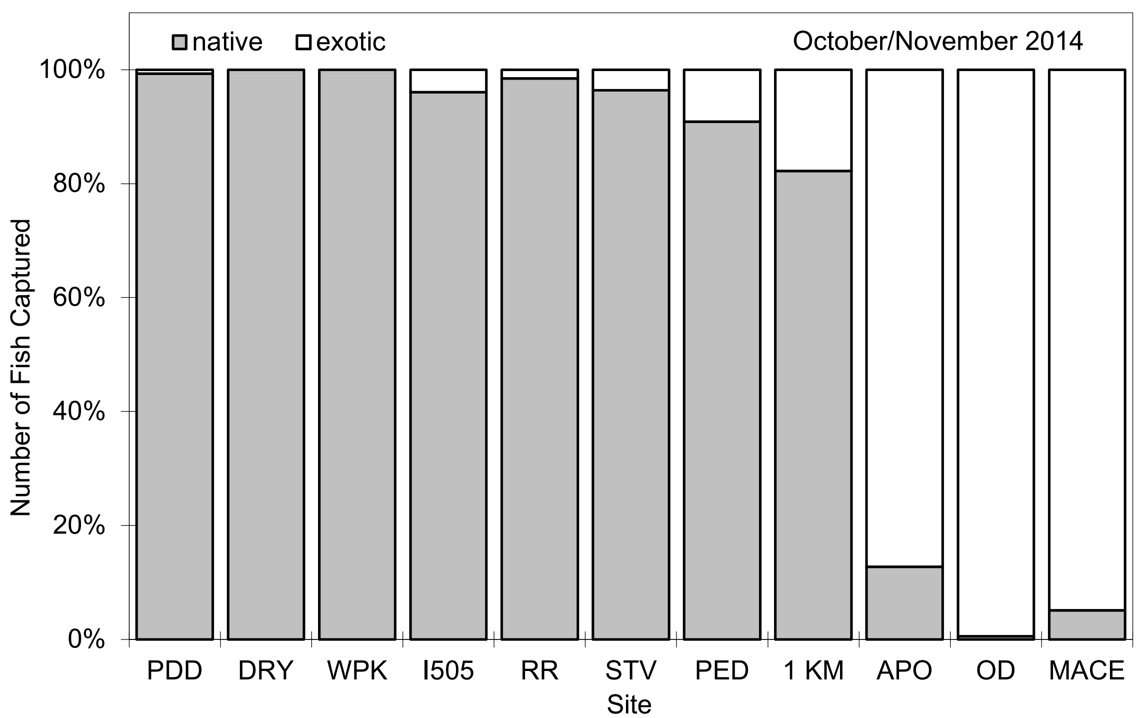

Figure 4. Percentage of native and exotic fish captured at each of the lower Putah Creek study sites during the October and early November 2014 fish surveys.

One noteworthy trend noted in the 2014 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 green sunfish, bluegill (*Lepomis macrochirus*), redear sunfish (*L. microlophus*), 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 28.1 percent of the total fish captures, and averaged 1,462 lepomids per survey. In the four complete, basin-wide surveys between 2010 and 2014, "lepomids" had declined to only 4.9 percent of the total captured fish, and averaged only 184 fish per survey. This is a decline of about 90 percent in "lepomids"/survey between the 2003-2008 and the 2010-2014 survey periods. The scarcity of "lepomids" in 2012 through 2014 is especially surprising since these three water years were all classified as below normal (or less) in the Sacramento Valley with few periods of natural high flows, that might disrupt sunfish spawning. 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 smaller "lepomid" sunfish populations in lower Putah Creek, the larger centrarchids, such as the "micropterid" 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 6.8 percent of the total fish captures, and averaged 353 black bass per fall survey. In the four complete basin-wide surveys conducted from 2010-2014, black bass have made up 11.0 percent of the captures and have average 415 bass per survey. This is an increase of 18 percent in black bass per survey between the 2003-2008 and the 2010-2014 survey periods. So, while the smaller sunfish species have exhibited a decline in recent years, the basses have remained a dominant fish, especially in the downstream survey areas. Perhaps some species interactions are operating where black bass are helping to suppress the smaller sunfish in the lower basin through predation.

The 2014 survey included the Winters Park site, which represents a relatively new sample site along lower Putah Creek that has been surveyed only since 2012. 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, including salmonids. Fish salvage and relocation efforts conducted in the project area in September 2011 (prior to construction) included only one rainbow trout in this section of Putah Creek (Peter Moyle, personal communication). Since channel restoration, rainbow trout have regularly been captured in this area. Twenty rainbow trout were captured at the Winters Park site in October 2012, eight rainbow trout were captured in October 2013, and nine rainbow trout were captured in October 2014. During all three 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. The 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 from the Putah Diversion Dam to downstream of Pedrick Road. The 2015 water year is currently projected to be another dry or critical water year. 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.