Willow Creek Road 2nd Bridge Area Fish Passage Project
Jenner, Sonoma County, California
Final Fisheries Monitoring Report
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Executive Summary

The Willow Creek watershed contains some of the highest quality salmonid habitat in the Russian River watershed; however, years of adverse land use practices caused significant declines in fish populations. While many factors contributed to the decline, changes in the channel configuration at 2nd bridge restricted movement of fish both up and downstream through the lower Willow Creek valley. Through community collaboration, a new bridge was installed in 2011 and fish passage restored. During construction of the 2nd bridge project, the entire creek within the project reach was dewatered and all aquatic species were relocated. During these efforts, 21 juvenile coho salmon and 44 steelhead were relocated, indicating some usage of the lower Willow Creek valley by salmonids (PCI 2011). These juvenile coho salmon were the first documented since the last observation in 1995 (PCI 2005).

In the winter prior to construction and during the summer of construction, baseline fisheries monitoring of the upper watershed was initiated. During spawner and snorkel surveys, no adult fish or redds were detected; however, a modest number of juvenile steelhead were observed upstream of 3rd bridge. This small population of juvenile fish may have represented successful spawning by resident steelhead, as large resident fish were observed during snorkel surveys, or a small number of anadromous fish that successfully made it upstream during the highest of winter flows. No juvenile coho salmon were observed in the upper watershed, indicating that only the lower Willow Creek valley was being utilized by coho salmon. Since little spawning habitat exists below 3rd bridge and no juvenile coho were observed upstream of this location, these fish likely moved into the Willow Creek from other locations within the Russian River watershed (see below).

In the winter following completion of 2nd bridge, a marked increase in the number of adult steelhead occurred, as well as a few observations of coho salmon jacks.. Summer snorkel surveys also indicated an increase in the density of steelhead young-of-the-year. In the second year following construction, a continued increase in the number of adult salmonids and redds were observed, and the first successful spawning of coho salmon was documented since 1995 (PCI 2005). The upper watershed was well seeded with juvenile coho salmon during summer snorkels in summer 2013.

Within completion of the 2nd bridge project, the upper Willow Creek watershed was identified as a suitable release site for the Broodstock Program and juvenile coho were released in fall 2011 and 2012. Downstream migrant trapping, conducted during the spring of 2012 and 2013, documented the successful movement of fish out of the watershed during peak migration periods in March through June. In spring 2013, wild coho salmon smolts were also captured in the trap; since no wild juvenile coho salmon

were observed upstream of the trap location in the previous summer, these fish mostly liked moved into the upper watershed from other locations.

Pit tag arrays installed as part of the Broodstock Program also tracked the movement of fish within the Willow Creek watershed. In spring 2012, arrays documented the movement of fish from above 3rd to below 2nd bridge during the peak migration period. A small sample of fish traveled from above 3rd bridge to the lower antennas in an average of 3 to 8 days. Fish movements following the November 2012 release were documented through June 2013. A large percentage of the release fish moved downstream within 10 days of release coinciding with a large storm event. Tracking of fish from 2012 to 2013 documented a large percentage of fish overwintering below 3rd bridge. A majority of the fish movements during spring coincided with increases in stream flows.

Coho salmon released as part of the Broodstock Program were also documented at other monitoring locations in the lower Russian River watershed. Fish were detected moving upstream to Duncans Mills, Dutch Bill Creek, Green Valley Creek, and as far as Mark West Creek, which is over 40 kilometers upstream of Willow Creek. The same was true for PIT-tagged coho salmon, steelhead, and Chinook salmon released elsewhere in the watershed and moving into Willow Creek. The majority of the fish movements outside of their release streams occurred during high flows events. Several of these fish, including Chinook salmon, were observed well upstream of 3rd bridge. These results provide fascinating insight into how fish are moving and rearing in the larger Russian River watershed.

While fish are now returning to Willow Creek, monitoring efforts to continue to support the successful management of the fisheries are critical to their survival. Monitoring recommendations for future work in the watershed are provided in the *Final Project Report – Effectiveness Monitoring* prepared by PCI (PCI 2014).

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1 Introduction

Historically, the Willow Creek watershed, a tributary to the Russian River near the town of Jenner, Sonoma County, once supported thriving populations of federally and state-listed steelhead (*Oncorhynchus mykiss*) and coho salmon (*O. kisutch*). However, beginning in the 1960s, declines of salmonid population were documented due to a number of historical land use practices and watershed changes. One contributing factor was limited fish passage into the upper watershed at the 2nd bridge crossing (Figure 1). Through community and regulatory agency collaboration, efforts to restore passage through the replacement of six culverts at the bridge location with a single-span, precast concrete bridge were completed in the summer of 2011. A comprehensive fish monitoring program was implemented to assess the effectiveness of the installation of the new bridge to re-establish fish passage and colonization of the watershed. This report summarizes three years of fisheries monitoring results including work completed as part of the Russian River Coho Salmon Captive Broodstock Program (Broodstock Program).

2 Fish Monitoring Methods

Fisheries monitoring of the Willow Creek watershed as part of the 2nd bridge project occurred from summer 2011 through summer 2013. Monitoring was a collaborative effort between Jennifer Michaud, Prunuske Chatham, Inc., Joe Pecharich, NOAA Restoration Center, Mariska Obedzinski, Nicolas Bauer, and additional field biologists from University of California Cooperative Extension (UCCE)/CA Sea Grant, and Derek Acomb, California Department of Fish and Wildlife.

The primary components of the project validation monitoring included spawner/redd surveys in winter and juvenile snorkel surveys in the summer. Concurrently with the project validation monitoring, UCCE/CA Sea Grant began monitoring the success of coho salmon introductions as part of the Broodstock Program. In addition to winter spawning and summer rearing surveys, this basin-wide program included operation of a downstream migrant trap and PIT tag antenna arrays, both of which were installed in Willow Creek beginning in 2012. While not a formal component of the post-implementation monitoring for the bridge project, results from Broodstock Program are included here as they provide valuable insight into the success of the fish passage project and the overall effectiveness of coho salmon reintroductions within the watershed and the larger Russian River basin.

Adult spawner and redd surveys and juvenile presence/absence snorkel surveys were completed following protocols described in the California Salmonid Stream Habitat Restoration Manual (Flosi et al. 2002), Gallagher and Knechtle (2003), and UCCE protocols for the Russian River Coho Salmon Captive Broodstock Program (UCCE 2011, 2012). During surveys, the upper Willow Creek watershed was divided into two reaches

– 3rd bridge to Hunter's Camp (2.4 km reach) and Hunter's Camp to the bedrock falls (3.2 km reach). Several tributaries were also surveyed as time and conditions allowed (i.e., Pomo Campground tributary, unnamed tributary (below forks), and forks tributary; Figure 1). Additional habitat below 3rd bridge was also evaluated as described below.

2.1 Adult Spawner/Redd Surveys

The primary objectives of the spawner/redd surveys were to document the presence of spawning salmonids and determine spatial spawning distribution within the watershed. Adult surveys were completed from winter through early-spring to coincide with peak spawning periods of steelhead and coho salmon. Attempts were made to survey the watershed following the onset of winter rains at least every 2 weeks depending on rainfall, hydrological conditions, and turbidity. Surveys were postponed when flows were too high to ensure surveyor safety and visibility was restricted. Surveys consisted of wading upstream through the watershed making visual observations of adult fish presence (i.e., live fish and carcasses) and evidence of spawning activity (i.e., excavated redd or other substrate disturbance).

Data collected included information on the survey reach and team, weather conditions, stream visibility, and fish and redd observations. Surveys were concentrated upstream of 3rd bridge to the assumed limits of anadromy at the bedrock falls. The limits of each survey were determined by staff availability and stream conditions. For each live fish or carcass observed, fish were identified to species, sexed, aged, and measured. Condition of the fish was noted (i.e., hatchery fish with clipped adipose fin, spawned or not yet spawned, state of decay). For each redd or potential redd observed, each feature was assigned a unique identification code, fish were identified as present on the redd, and the redd was aged, and measured [i.e., pot dimensions (length, width, depth, substrate) and tail spill dimensions [i.e., tail spill dimensions (length, width, substrate). Geographic coordinates were taken and the location flagged for each redd observed.

2.2 Juvenile Presence/Absence Surveys

The primary objectives of the summer snorkel surveys were to document successful spawning through the presence of rearing juvenile salmonids, density of fish, and spatial distribution within the watershed. Juvenile surveys were completed during the summer rearing period, typically late-July through September each year. Surveys were completed in summer 2011 prior to installation of 2nd bridge and post project implementation in summer 2012 and 2013. Snorkel surveys were concentrated upstream of 3rd bridge where adult spawning was likely to occur. Reconnaissance surveys of the lower reaches of the watershed were completed in between 2nd and 3rd bridge and below 2nd bridge in 2011 and 2012, respectively.

Surveys were completed by divers equipped with a wetsuit or dry suit, snorkel, mask, and underwater dive light. Divers would enter a pool at the downstream end and slowly

work their way upstream observing and counting all steelhead and coho salmon present within the main channel and microhabitats within the unit (i.e., undercut banks, rootwads). Presence of all other native fish and aquatic vertebrates were also noted. Data recorded for each dive survey included survey reach and team, weather conditions, stream visibility, and fish composition and approximate numbers by pool. Pools were randomly sampled during 2011 and every third pool was sampled in 2012 and 2013.

Monitoring reaches and points of interest are included in Figure 1. A timeline of all monitoring activities is provided below in Table.

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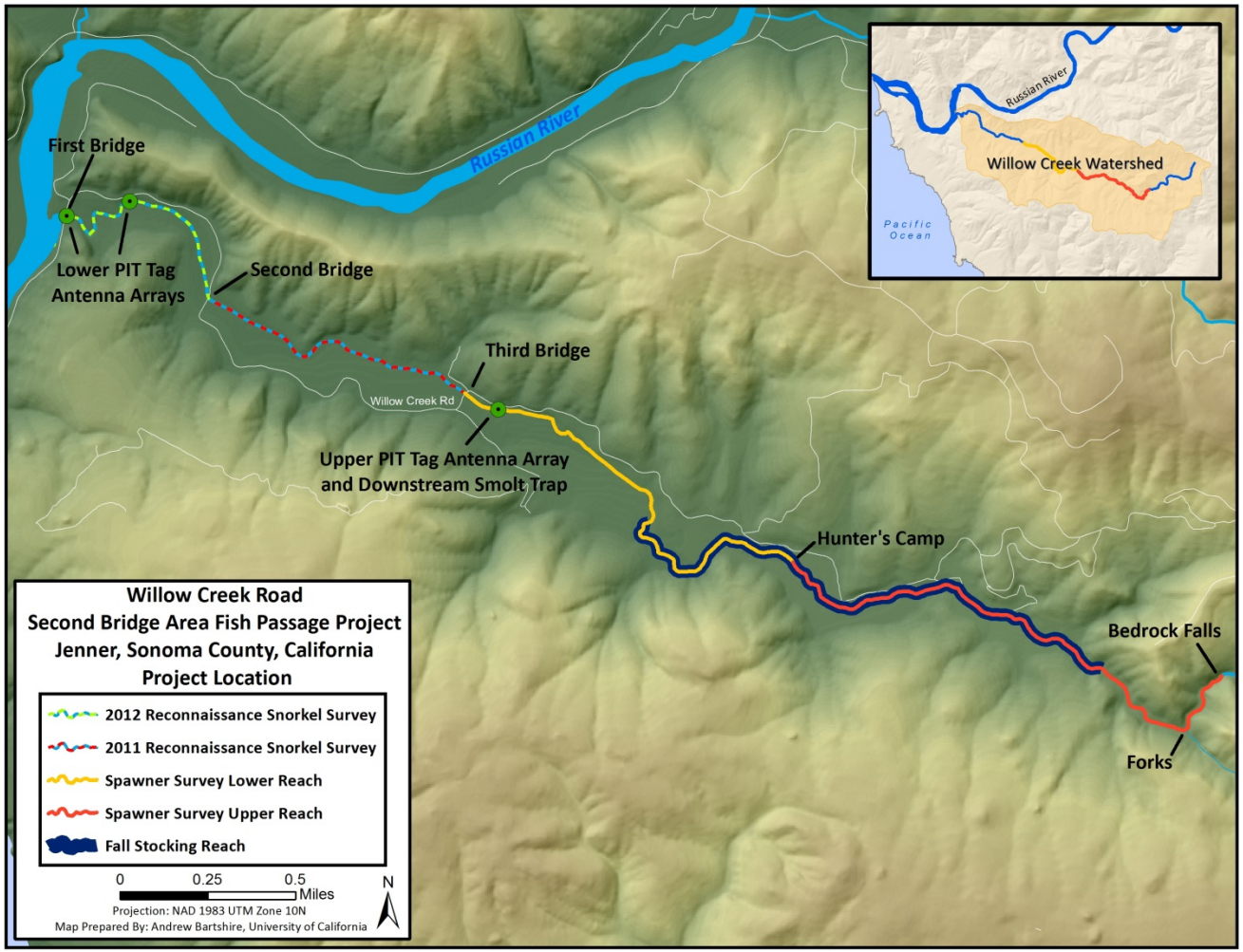

Figure 1. Willow Creek Monitoring Locations

Table 1. Willow Creek Fisheries Monitoring Timeline

Year:	2011												2012												2013								
Task/Month	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S
2nd bridge construction																																	
Spawner/redd surveys																																	
Juvenile surveys																																	
Coho salmon releases																																	
Downstream migrant trapping																																	
PIT tag antenna arrays																																	

3.3 Downstream Migrant Trapping

The primary objectives of operating a downstream migrant trap were to estimate the number and migration timing of smolts migrating out of Willow Creek in the spring, and to estimate overwinter growth of juvenile hatchery coho salmon released in the fall. A funnel net and box trap was installed and operated at river kilometer 3.69 from May 4, 2012 to June 14, 2012 and March 6, 2013 to June 14, 2013 (Figure 1). While the trap was in operation, it was checked a minimum of one time per day and more frequently during high flow or wind events. Each day upon arrival, fish were first netted into aerated buckets prior to sampling. Juvenile salmonids were anesthetized, measured for length and weight, and scanned for presence of a PIT tag and/or coded-wire tag. Each salmonid was also checked for the presence of an adipose fin clip to determine whether it was a hatchery-released fish (clipped adipose fin) or a wild fish (intact adipose fin). Wild coho salmon and up to five hatchery coho salmon per day received a lower caudal fin clip for subsequent genetics analysis. Juvenile steelhead were measured for length and weight. All other fish, amphibians, crustaceans and other aquatic species were tallied. After processing, fish were placed into aerated buckets for recovery and then released downstream of the trap. Before leaving the trap site, debris was removed from the weir, net and box, and the trap was inspected for holes or other potential problems.

A two-trap mark recapture design (Bjorkstedt 2005, 2010) was used to estimate the total number of smolts leaving the creek during the time that the trap was in operation. PIT-tagged fish passing over a PIT tag antenna located immediately upstream of the trap served as the marking event, and fish captured in the trap served as the recapture event. PIT-tagged fish detected at both the antenna and in the trap were counted as recaptures, and the sum of non-PIT-tagged fish and PIT-tagged fish only detected in the trap were counted as unmarked fish.

3.4 PIT Tag Antenna Arrays

PIT tag antennas and transceivers were installed and operated in Willow Creek to document movement patterns, survival, and abundance of PIT-tagged coho salmon released into the watershed as part of the Broodstock Program. On October 18, 2011, the Army Corps of Engineers released a total of 11,062 young-of-year coho into Willow Creek between 3rd bridge and the bedrock falls (Figure 1). Of these fish, 804 (7%) were PIT-tagged at Don Clausen Warm Springs Hatchery prior to release. The following year, on November 14, 2012, a total of 22,151 young-of-year coho were released in the same reach, 4,381 of which were PIT tagged (~20%).

During the first week in May, 2012, two PIT tag antenna arrays were installed in Willow Creek (Photos 1 - 4). One array was placed at river kilometers 3.69 and 3.70, upstream of 3rd bridge, and the second was placed at river kilometers 0.97 and 0.98 (below 2nd bridge). The upper array consisted of two 16’ upright antennas, one located immediately upstream of the other, and upstream of the downstream migrant trap

(Figure 1). During all but the highest winter flow events, this array spanned the width of the stream channel, capturing all of the flow passing by the site. The second array (below 2nd bridge) consisted of two 10' upright antennas that spanned one of multiple channels flowing through lower Willow Creek (Figure 1). Although the channel appeared to carry the majority of the flow, the antennas did not capture all movement pathways for fish migrating to and from lower Willow Creek.

On December 11, 2012, as a pilot project to test new PIT tag technology, a 16' single flat plate PIT tag antenna was installed approximately 50' upstream of 1st bridge at river kilometer 0.41 (Figure 1). On May 7, three additional flat plate antennas were installed to complete the array, spanning the channel with an upstream and downstream component. Following full installation of this array, the array at river kilometers 0.97 and 0.98 was removed.

Once installed, all PIT tag antenna arrays were checked biweekly (3.69/3.70 and 0.97/0.98), or weekly (0.41). More frequent checks occurred during storm events. During each check, a test PIT tag was placed in the antenna field to confirm that the antenna was functioning, any debris that collected on the antennas was removed, batteries were changed, and data was downloaded if detections of fish occurred since the previous check.

Photos 1 - 4. Flat plat antenna location at 1st bridge (Photo1, top left), paired upright antenna between 1st and 2nd bridge (Photo 2, top right), and paired upright antenna and downstream migrant trap above 3rd bridge (Photo 3, looking upstream – bottom left and Photo 4, looking downstream – bottom right).

3 Results

The following includes a summary of the results of the winter adult spawner/redd surveys and summer juvenile snorkel surveys completed prior to installation of 2nd bridge (winter 2011 and summer 2011) and post-implementation (winter 2011-2012, summer 2012, winter 2012-2013, and summer 2013) as part of the project validation monitoring. Monitoring locations and other points of interest are included in Figure 1. Snorkel observations are summarized in Figures 2 and 3. Spawning and snorkeling observations are summarized in Table 2. Winter spawning and summer snorkel survey details including specific dates, reaches, and observations are included in Table 6 at the end of this report. A summary of the Broodstock Program monitoring by UCCE/CA Sea Grant is described below.

3.1 Adult Spawner/Redd Survey Results

Winter 2011. Prior to completion of the 2nd bridge project, spawner surveys were completed in the upper reaches of the watershed, 3rd bridge to the bedrock falls, from February through March 2011. Surveys coincided with the drop in stream flows following several large storm events in February and late-March during the peak steelhead spawning season[1]. During the winter 2011 surveys, no carcasses, redds, or other substrate disturbance were noted. Only a single small (≈30cm fork length) fish was observed, but it was unidentifiable to species.

Winter 2011-2012. Following construction of 2nd bridge and increased stream flows after significant rainfall in December 2011, spawning surveys were initiated in the upper reaches of the watershed, including the Pomo Campground tributary. However, conditions were unsuitable for surveying until early February following a second winter storm series. Throughout the winter, eight survey attempts were made, but only five were completed under safe conditions with suitable visibility. From mid-February through early April, four adult salmonids [one 60cm male steelhead, one adult female unknown, and one 50cm adult unknown, and one adult unknown]; eight jacks (four coho jacks and four unknown species, ranging in size from 25 to 35cm, several coho jacks were of hatchery origin with adipose fin clips); and several pairs of small steelhead were observed (Photos 10 and 11).

Only one complete redd was observed in February 2012. This redd was midway between Hunter's Camp and the forks. The pot measured 0.5m long, 0.85m wide, and 0.1m deep. The tail spill was 0.8m long and 0.8 and 0.5m wide. It was unattended by a fish. Two additional areas of substrate disturbance were noted, one in the location of a jack observation; however, these were likely test redds and not used for successful spawning.

[1] Photos 5 through 9 depict winter base flows in mainstem Willow Creek and the two main tributaries.

Winter 2012-2013. Throughout the 2012-2013 spawning season, eight surveys of mainstem Willow Creek and the two upper tributaries were completed. During the surveys, crews observed one adult female carcass below Hunter's Camp. Based on the skin fragments present, it was estimated this unidentifiable fish was approximately 60 cm (Photo 12). Adjacent to the skin was a small pile of eggs and river otter scat (Photo 13). The presence of the scat suggested the otter might have been the source of mortality for this particular fish. An adult steelhead (60 cm) with an adipose clip was observed on two occasions near the downstream migrant trap. It was assumed this fish was the same individual as it was in the same exact location on two separate occasions. A second adult carcass was observed near 3rd bridge and several small steelhead residents or jacks were observed below Hunter's Camp.

Only one complete redd was observed in January 2013. This redd was midway between 3rd bridge and Hunter's Camp. The pot measured 0.65m long, 0.5m wide, and 0.12m deep. The tail spill was 0.8m long and 0.6 and 0.3m wide. It was unattended by a fish. An area of disturbance was noted near the forks, but could not be positively confirmed as a spawning attempt.

Photos 5 – 9. Winter base flow conditions below Hunter's Camp (Photo 5, top left), above Hunter's Camp (Photo 6, top right), bedrock falls on mainstem Willow Creek (Photo 7, middle left), unnamed tributary waterfall (Photo 8, bottom right), and fork tributary (Photo 9, bottom left).

Photos 10 - 13. Coho jack below Hunter's Camp (Photo 10, top left) and adult steelhead (Photo 11, top right, lower left of photo) above Hunter's Camp, both observed during winter 2011-2012 spawning surveys. Unknown salmonid skin (Photo 12, bottom left) and egg mass (Photo 13, bottom right) observed in January 2013. River otter scat was observed nearby and might have likely been the source of mortality for this fish.

3.2 Juvenile Presence/Absence Survey Results

Summer 2011. Prior to completion of the bridge project, snorkel surveys were completed in the wetland reach between 2nd and 3rd bridge and from 3rd bridge to below the forks (Figure 1). In September 2011, six pools were surveyed within the wetland. Due to poor visibility, observations were limited to schools of threespine stickleback and one 2+ steelhead. On the same day, the team snorkeled 22 pools between 3rd bridge and Hunter's Camp. Fish observed in this reach included one steelhead yoy, 18 steelhead parr/residents, schools of threespine stickleback, and prickly sculpin. On the following day, 41 pools were surveyed between Hunter's Camp to below forks. Fish observed in this reach included 98 steelhead yoy, 35 steelhead parr/residents, prickly sculpin, and signal crayfish. In total, 63 pools were surveyed above 3rd bridge in 2011 and 99 steelhead yoy and 53 steelhead parr/residents were documented (Table 2).

Summer 2012. In the summer following completion of the bridge project, snorkel surveys were completed below 2nd bridge in select pools in the historic channel and main channel and from 3rd bridge to above the forks (Figure 1). In August 2012, 18 pools surveyed between the lower paired antenna and 2nd bridge. Due to poor visibility, observations were limited to schools of threespine stickleback, prickly sculpin, and rough-skinned newt.

In September 2012, the survey team snorkeled 60 pools between 3rd bridge and Hunter's Camp. Fish observed in this reach included 103 steelhead yoy, 267 steelhead parr/residents, schools of threespine stickleback, signal crayfish, possible pike minnow, prickly sculpin, one coho salmon smolt with a clipped adipose fin, and California red-legged frog. Upstream of Hunter's Camp to just above the bedrock falls, 59 pools were surveyed. Fish observed in this reach included 321 steelhead yoy, 76 steelhead parr/residents, schools of threespine stickleback, signal crayfish, prickly sculpin, and California giant salamander.

The largest concentration of steelhead young-of-the-year (yoy) were documented in an approximately 0.4 mile reach near the forks and below the bedrock falls (Figure 2). In this reach, 231 (54%) steelhead yoy were observed. Throughout the remaining portions of the reaches surveyed, steelhead yoy were evenly distributed. In total, 119 pools were surveyed above 3rd bridge. A total of 424 steelhead yoy and 343 steelhead parr/residents were documented (Table 2). One hatchery coho salmon parr was observed during the 2012 surveys.

Summer 2013. Snorkel surveys in summer 2013 were completed from 3rd bridge to the bedrock falls (Photos 14 – 17). The survey team snorkeled 57 pools between 3rd bridge and Hunter's Camp. Fish observed in this reach included 28 steelhead yoy, 17 steelhead

parr/residents, 11 coho salmon yoy, one coho salmon parr, and one Chinook salmon parr. Upstream of Hunter's Camp to the bedrock falls, 58 pools were surveyed. Fish observed in this reach included 72 steelhead yoy, five steelhead parr/residents, 210 coho salmon yoy, six coho salmon parr, and one Chinook salmon parr. Additional species observed included sculpin, signal crayfish, Sacramento pikeminnow, and threespine stickleback.

The largest concentration of steelhead young-of-the-year (yoy) were documented in an approximately 0.25 mile reach below the unnamed tributary (Figure 3). In this reach, 35 (35%) steelhead yoy were observed. Small numbers of steelhead yoy were distributed throughout the remaining reaches surveyed with the exception of Hunter's Camp and just above 3rd bridge where very few fish were observed.

The highest density of coho salmon yoy were observed in an approximately 0.4 mile reach below the bedrock falls at the forks (Figure 3). Of the 15 pools surveyed in this reach, 156 (70%) coho salmon yoy were observed. At least four pools, had densities of 20 fish or more. Two pools had 26 fish each. The majority of coho salmon yoy were observed above the pull out along Willow Creek Road to the bedrock falls. In total, 115 pools were surveyed above 3rd bridge in 2013. A total of 100 steelhead yoy, 22 steelhead parr/residents, 221 wild coho salmon yoy, seven coho salmon parr, and two Chinook salmon parr were observed.

Photos 14 – 17. Juvenile coho salmon observed in Willow Creek in summer 2013 (Photo 14 and 15, top left and right, photos by Derek Acomb). Diver snorkeling pool during summer survey (Photo 16, bottom left). Juvenile steelhead observed during snorkel survey in 2013 (Photo 17, bottom right).

Table 2. Summary of Spawning and Snorkel Survey Observations

	Survey Year		
	2011	**2012**	**2013**
Adult Spawner/Redd Surveys			
Number of surveys	3	5	8
Adult salmonids	0	4	3
Redds (complete)	0	1	1
Redds (partial or under construction)	0	2	1
Salmonid jacks	0	8	1
Juvenile Presence/Absence Surveys			
Number of pools surveyed (above third bridge)	63	119[2]	115
Frequency of pools sampled	random	every 3rd pool	every 3rd pool
Coho salmon yoy	0	0	221
Coho salmon parr	0	1	7
Steelhead yoy	99	424	100
Steelhead parr/resident	53	343	22
Chinook salmon parr	0	0	2
Summary Statistics			
Average number of steelhead yoy observed per pool	1.43	3.56	0.87
Range of steelhead yoy observed per pool	0 – 10	0 – 43	0 - 10
Average number of coho salmon yoy observed per pool	-	-	1.92
Range of coho salmon yoy observed per pool	-	-	0 - 26

[2] In 2012, 60 pools were surveyed between 3rd bridge and Hunter's Camp and 59 pools between Hunter's Camp and the bedrock falls. In 2013, 57 and 58 pools were sampled in the same reaches.

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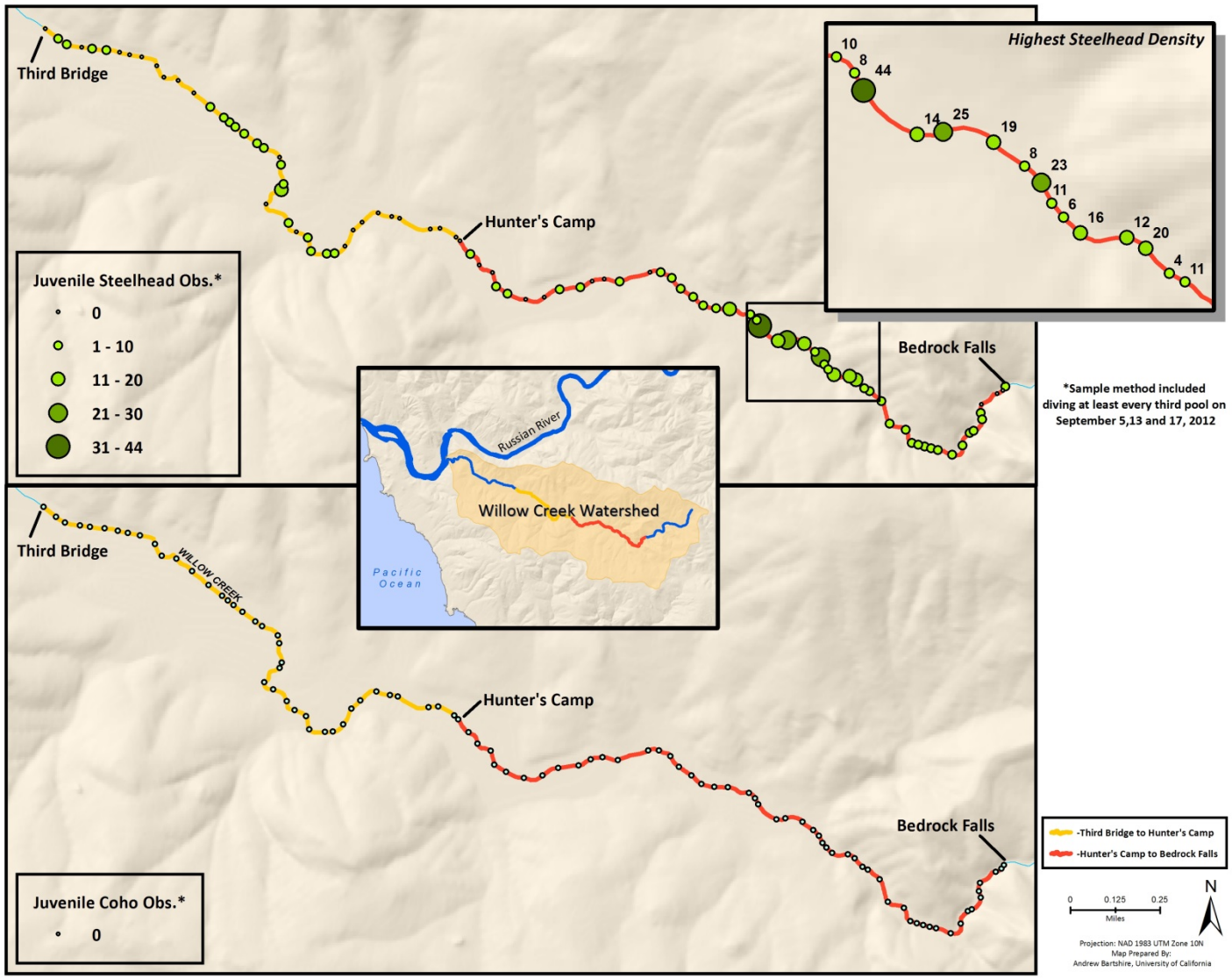


Figure 2. Juvenile Salmonid Distribution Upper Willow Creek – 2012 Snorkel Surveys

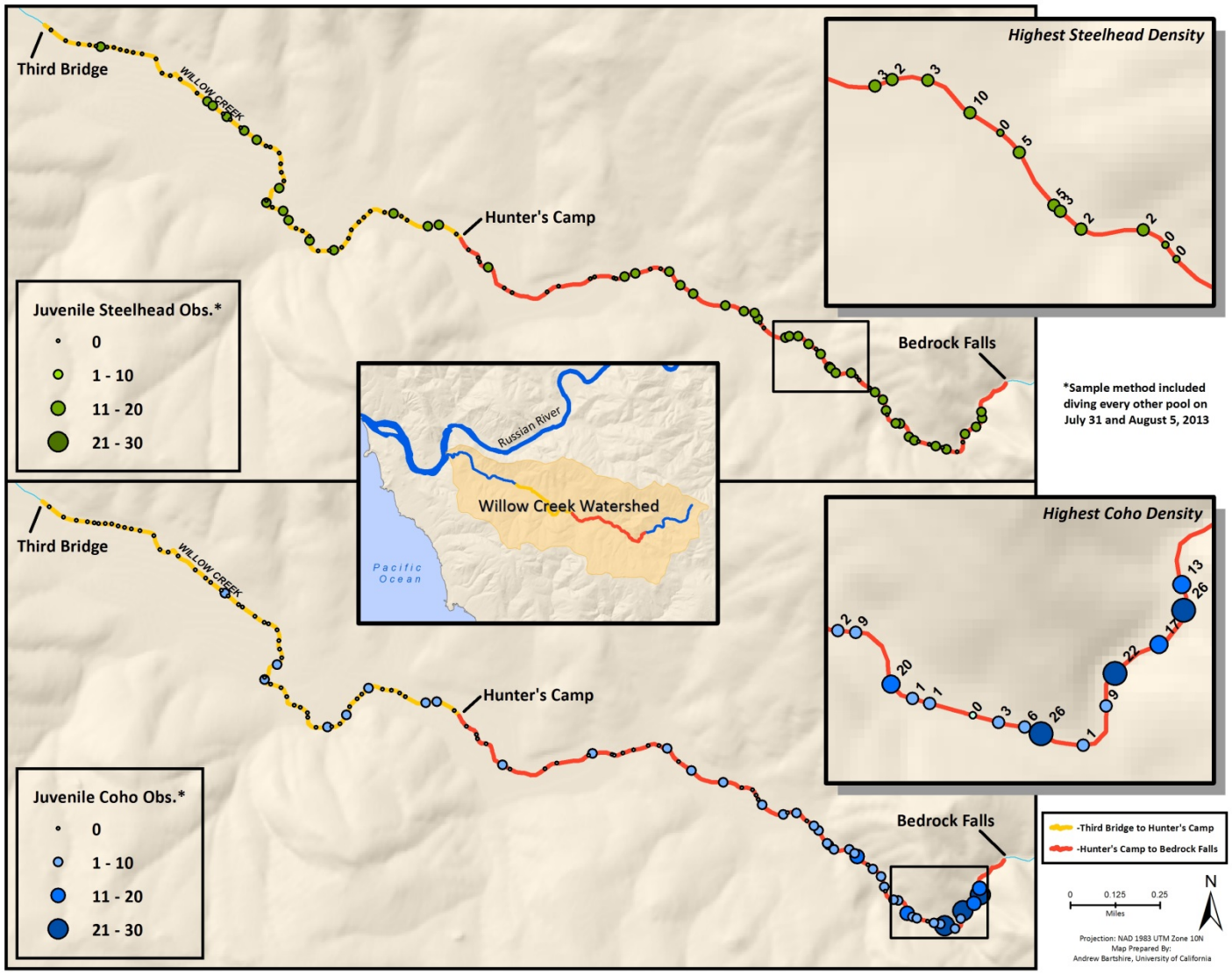


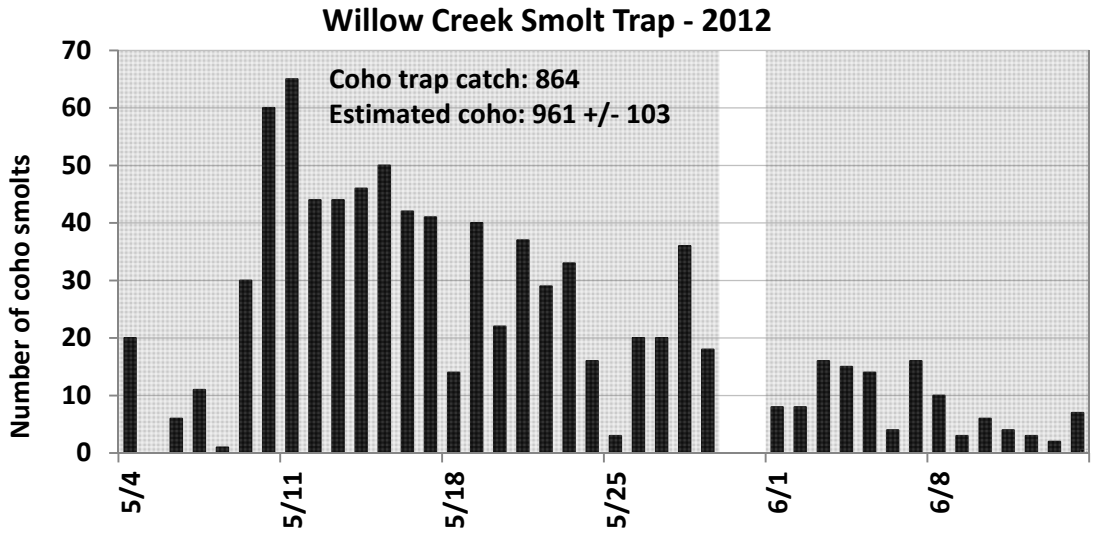
Figure 3. Juvenile Salmonid Distribution Upper Willow Creek – 2012 Snorkel Surveys

3.3 Downstream Migrant Trapping

Spring 2012

During the spring of 2012, the downstream migrant trap was installed on May 4, and, with the exception of two days at the end of May, ran continually through June 14. In other Russian River tributaries, the coho salmon smolt migration period typically begins in early March and ends in mid-June (UCCE unpublished data), so it is likely that a significant number of coho salmon smolts emigrated from Willow Creek prior to trap installation. The estimate of smolt abundance for this year should therefore be considered a minimum estimate.

A total of 864 hatchery coho smolts were captured in the downstream migrant trap over the course of trap operation with peak numbers occurring during the second week of May (Graph 1). The estimated number that passed the site was 961 +/- 103 (95% CI). Other species captured included juvenile steelhead, sculpin sp., threespine stickleback, Sacramento sucker, and California red-legged frog (Table 3, Photos 18 - 21).



Graph 1. Number of coho smolts detected daily at downstream migrant trap operated on Willow Creek during spring 2012. Shaded background represents days that the trap was in operation.

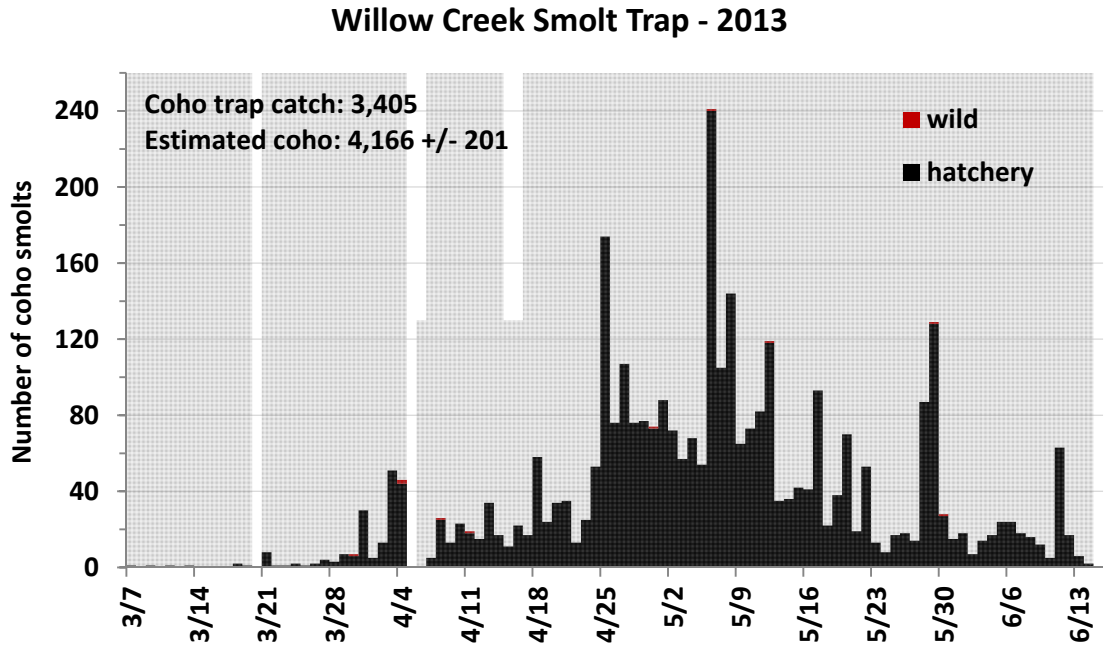
Table 3. Number of Individuals Captured in Willow Creek Downstream Migrant Trap During Spring 2012 and 2013.

	Trap Count	
Species	**5/4/2012 to 6/14/2012**	**3/7/2013 to 6/14/2013**
Wild coho salmon smolts	0	12
Hatchery coho smolts	864	3,385
Coho smolts unknown origin	0	8
Hatchery steelhead adults	0	1
Steelhead smolts	5	25
Steelhead yoy/parr	26	142
Sculpin sp.	339	4,206
Threespine stickleback	383	268
Sacramento sucker	1	24
Sacramento pikeminnow	0	219
California roach	0	1
California red-legged frog	1	1
California giant salamander	0	1
Rough skinned newt	0	3

Photos 18 - 21. UCCE biologist processing fish captured in downstream migrant trap (Photo 18, top). Individuals captured in the trap – sculpin (Photo 19, middle left), California red-legged frog (Photo 20, middle right), and coho salmon (Photo 20, bottom).

Spring 2013

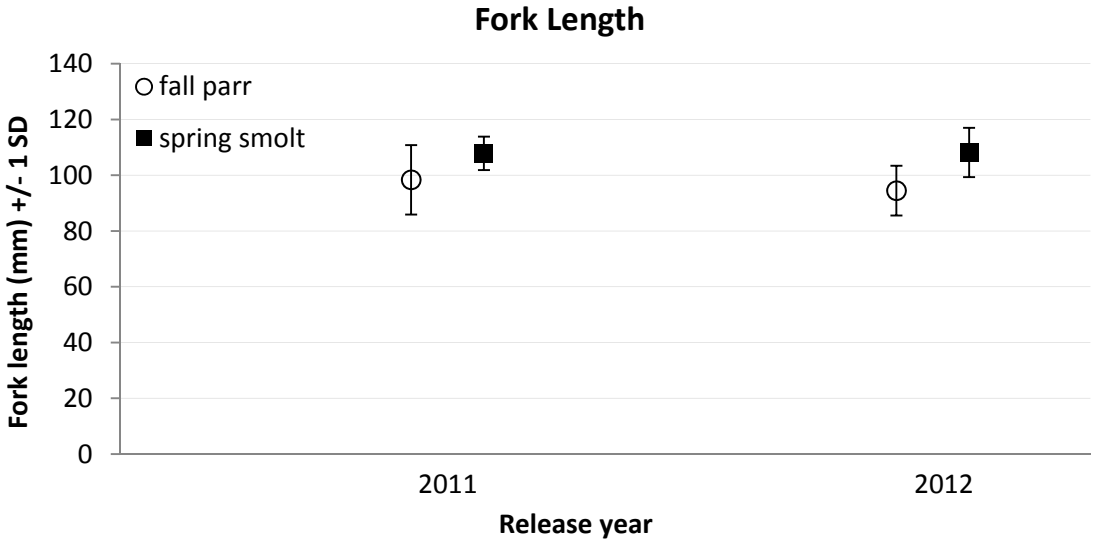
The downstream migrant trap was installed on March 7, 2013 and continued to operate through June 14, 2013. On one occasion in March and two occasions in April, trap operation was suspended for a day due to high flow events. Between March 7 and June 14, 2013, a total of 3,405 coho salmon were captured in the trap, including 12 coho of wild origin (Graph 2). The estimated number of coho smolts passing the site during this time period was 4,166 +/- 201 (95% CI). Counts of steelhead and all other species captured in the trap during spring 2013 are provided in Table 3 above.



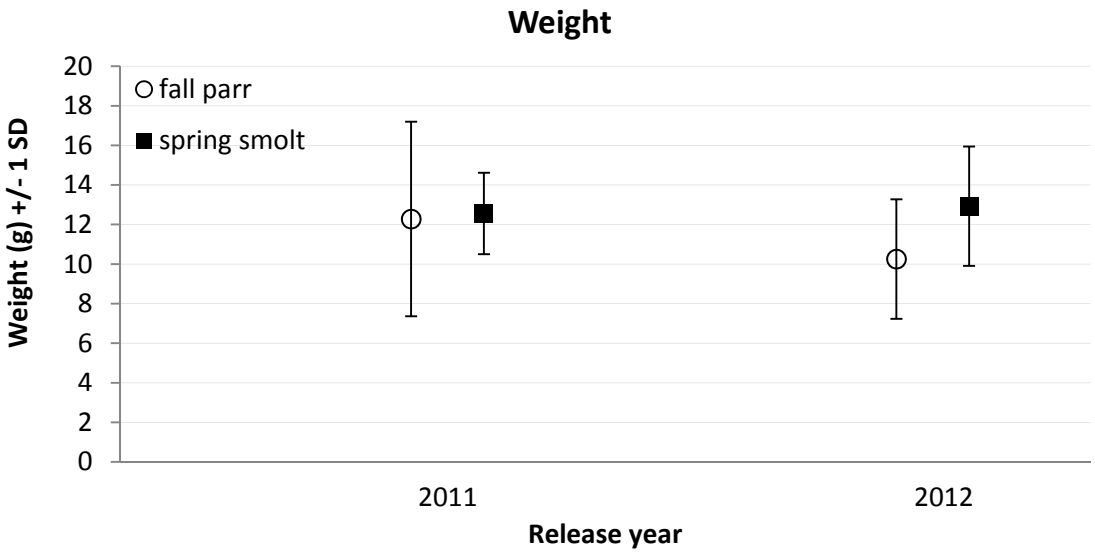
Graph 2. Number of coho smolts detected daily at downstream migrant trap operated on Willow Creek during spring 2013. Shaded background represents days that the trap was in operation.

Size and growth

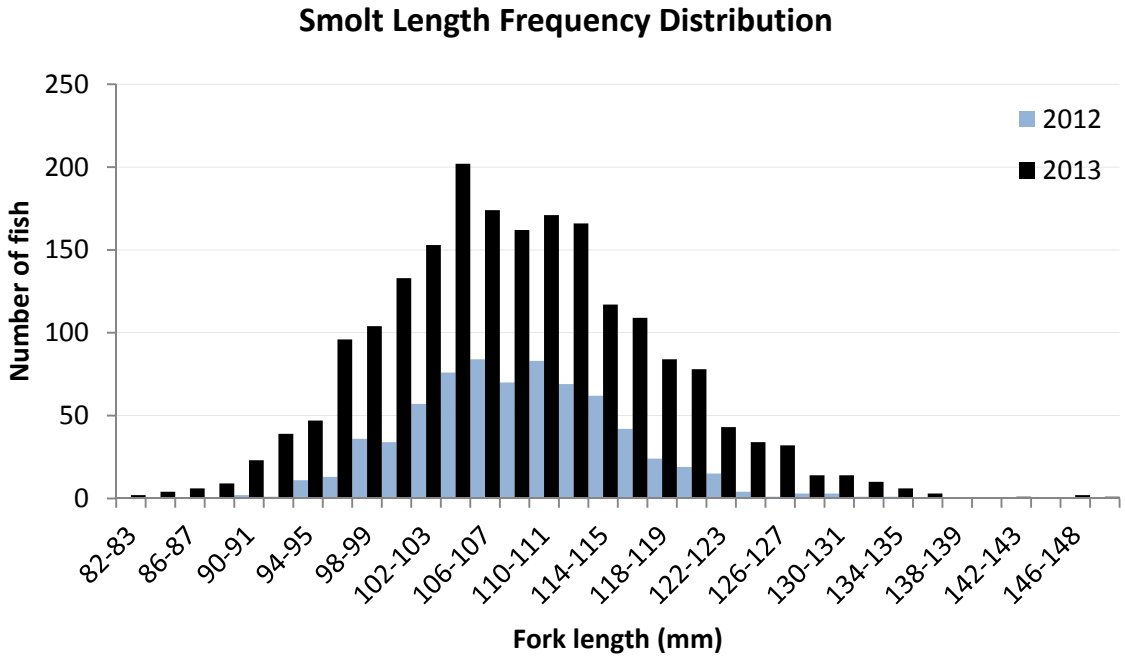
Size of PIT-tagged individuals that were captured and measured at the smolt trap were compared with sizes of individuals measured at the hatchery prior to their release the previous fall (Graph 3, 4). Although fall parr fork length varied slightly between years (98 +/- 12mm and 94+/- 9 mm), average fork length as smolts was similar (108 +/- 6 mm and 108 +/- 9 mm) (Graph 3, 5). Daily growth rates were low and slightly higher during the winter of 2012-2013 (Graph 6).



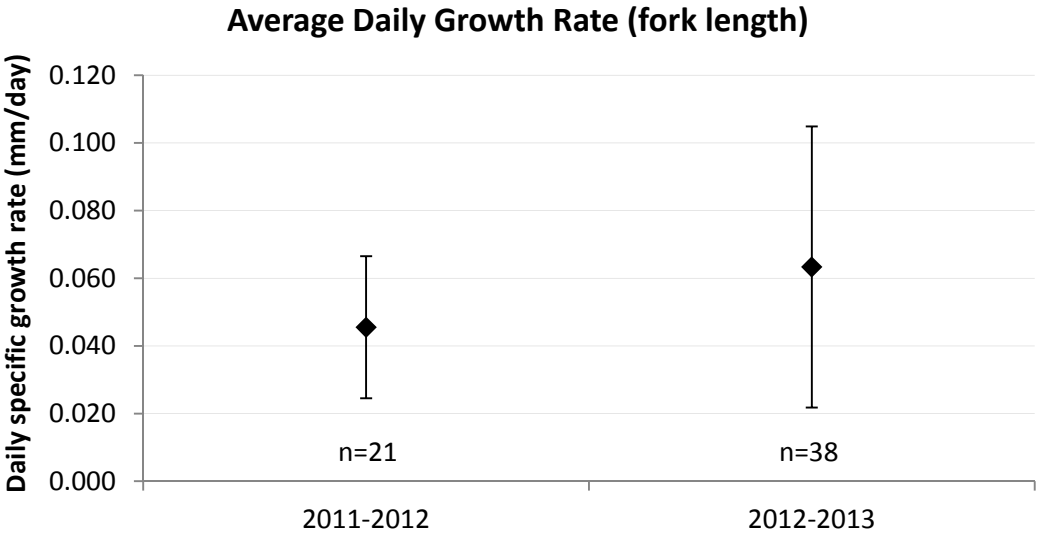
Graph 3. Average fork length of PIT-tagged individuals measured as fall parr (approximately one week prior to release from Don Clausen Warm Springs hatchery) and as spring smolts (measured upon capture in the downstream migrant trap).



Graph 4. Average weight of PIT-tagged individuals measured as fall parr (approximately one week prior to release from Don Clausen Warm Springs hatchery) and as spring smolts (measured upon capture in the downstream migrant trap).



Graph 5. Length frequency distribution of all measured hatchery coho smolts captured in the downstream migrant trap during spring 2012 and spring 2013.

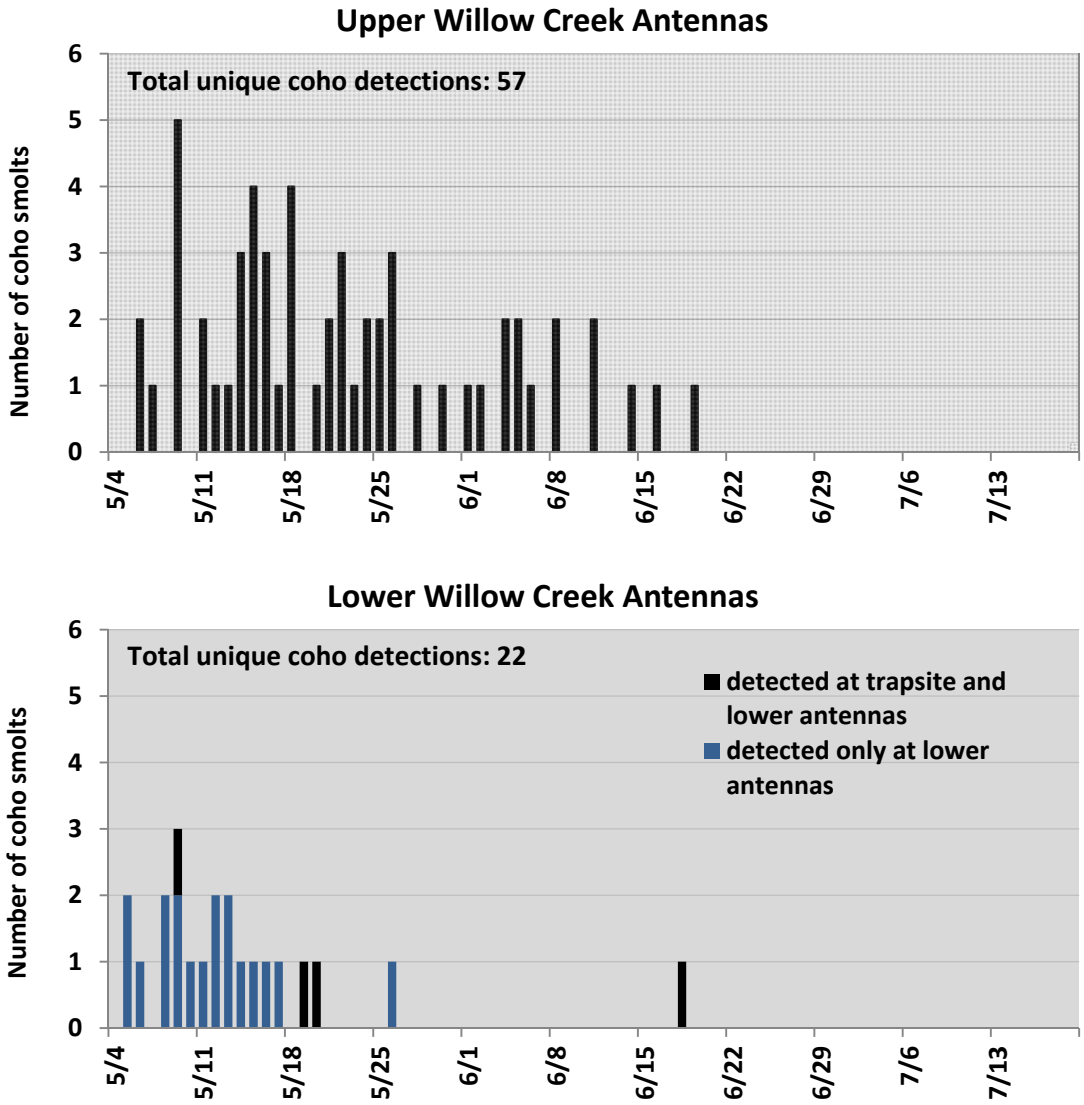


Graph 6. Average daily growth rate of PIT-tagged individuals measured as fall parr (approximately one week prior to release from Don Clausen Warm Springs hatchery) and recaptured as spring smolts (measured upon capture in the downstream migrant trap).

3.4 PIT Tag Antenna Arrays

2011-2012

PIT tag antenna arrays were installed at an upper Willow Creek site upstream of 3rd bridge (river kilometers 3.69 and 3.70) and a lower Willow Creek site upstream of 1st bridge (river kilometers 0.97 and 0.98) on May 4, 2012 and ran continuously through the end of July. A total of 57 unique PIT-tagged coho were detected at the upper array and 22 were detected at the lower array (Graph 7). Of the 22 individuals detected at the lower array, four were previously detected at the upper antenna, and 18 were not. It is likely that these 18 fish migrated downstream of the upper array prior to antenna installation. Travel time for the four fish detected at both sites ranged from three to eight days. The majority of the fish were detected moving in early to mid-May, with no detections after June 19. One coho detected moving downstream on the lower antennas on May 15, 2012 originated from a Dutch Bill Creek release on November 3, 2011. Additionally, one steelhead that was PIT tagged on June 12, 2012 at a Sonoma County Water Agency downstream migrant trap at the mouth of Austin Creek, was subsequently detected moving upstream at the lower Willow antennas on July 11, 2012.

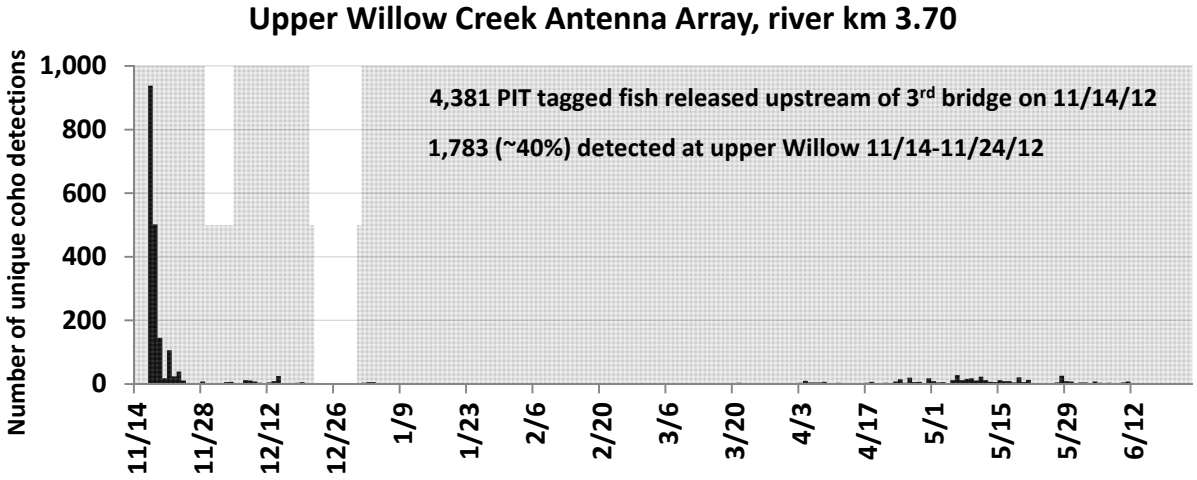


Graph 7. Unique PIT-tagged coho detections at antennas operated at upper and lower antenna arrays in Willow Creek, spring 2012. Shaded background represents days that the antennas were in operation.

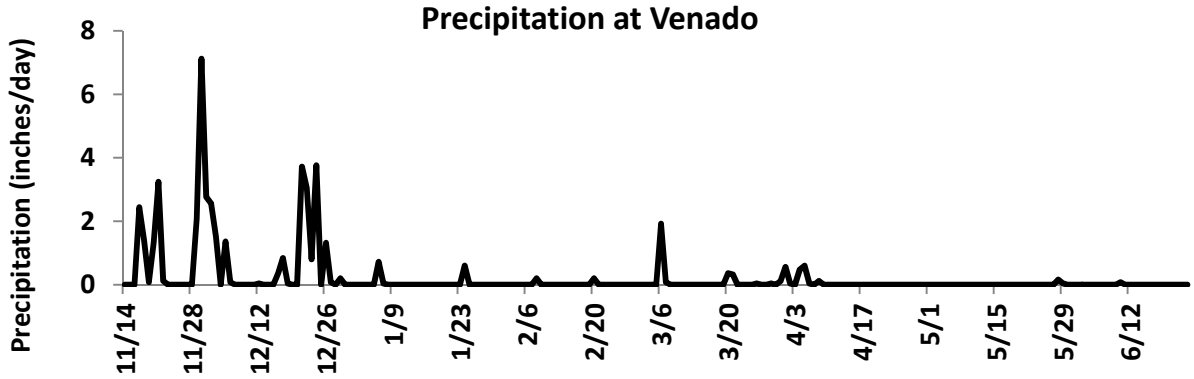
2012-2013

With the exception of occasional high flow events where antennas were washed to the stream bank, the upper array and at least one antenna in the lower arrays were in continuous operation from spring 2012 through the end of 2013. Between mid-June and mid-November 2012, no fish were detected. Following the release of 4,381 PIT-tagged hatchery coho on November 14, 2012, PIT-tagged fish were detected through the middle of June 2013.

Between November 14 and 24, 2012, 1,783 PIT tagged coho were detected at the upper antenna within 10 days after their release. This was likely related to a large rain event that occurred immediately after the release; approximately 7-inches of rain fell between November 14 and 24, 2012 (Graph 8, 9).

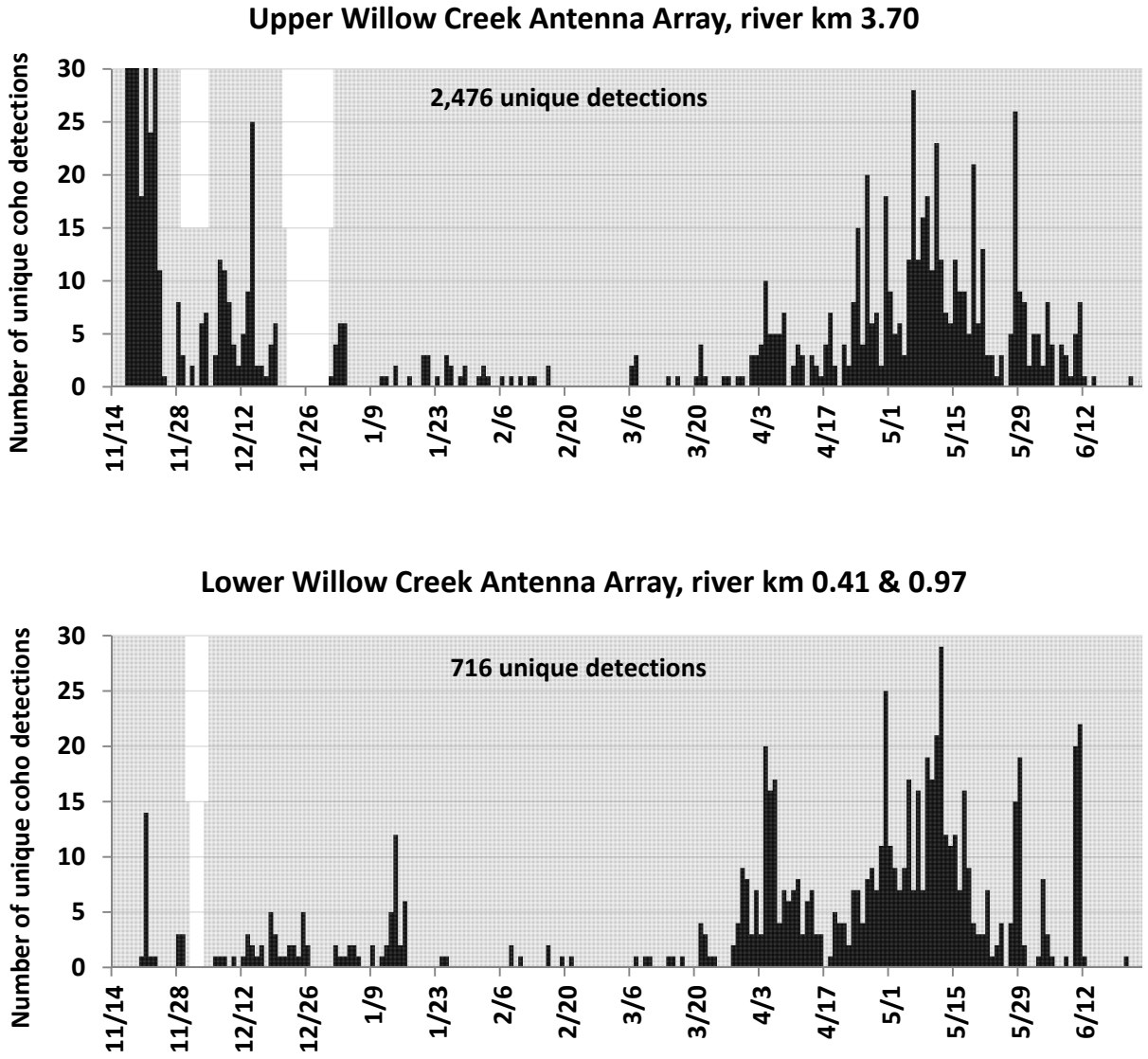


Graph 8. Unique PIT-tagged coho detections on upper antenna array in Willow Creek, spring 2013. Shaded background represents days that the antennas were in operation.



Graph 9. Total daily precipitation at Venado gauge, California Nevada River Forecast Center, NOAA.

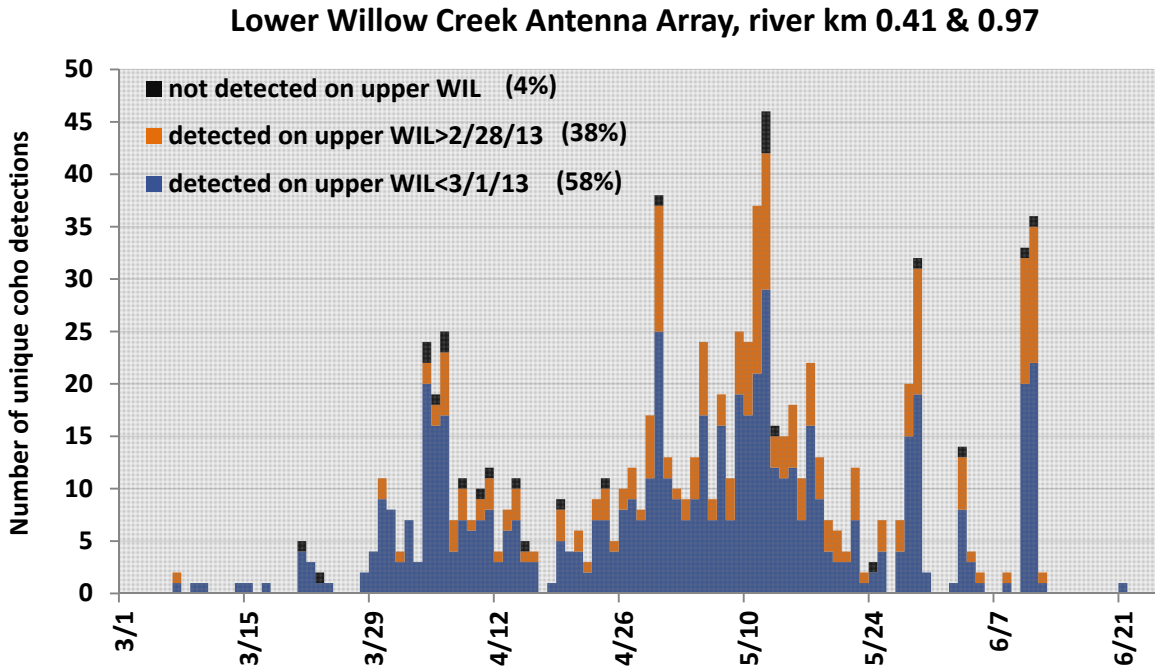
A total of 2,476 unique PIT-tagged coho were detected at the upper site above 3rd bridge from November 14, 2012 and June 21, 2013, and 716 were detected at the lower sites near the confluence during the same time period (Graph 10).



Graph 10. Unique PIT-tagged coho detections at antennas operated at upper and lower antenna arrays in Willow Creek, spring 2013. Shaded background represents days that the antenna array was in operation. Note that the figure for the upper array is the same as Graph 8, but scaled lower to depict more detail during the spring season.

3.5 Evidence of Juvenile Coho Salmon Overwintering in Lower Willow Creek

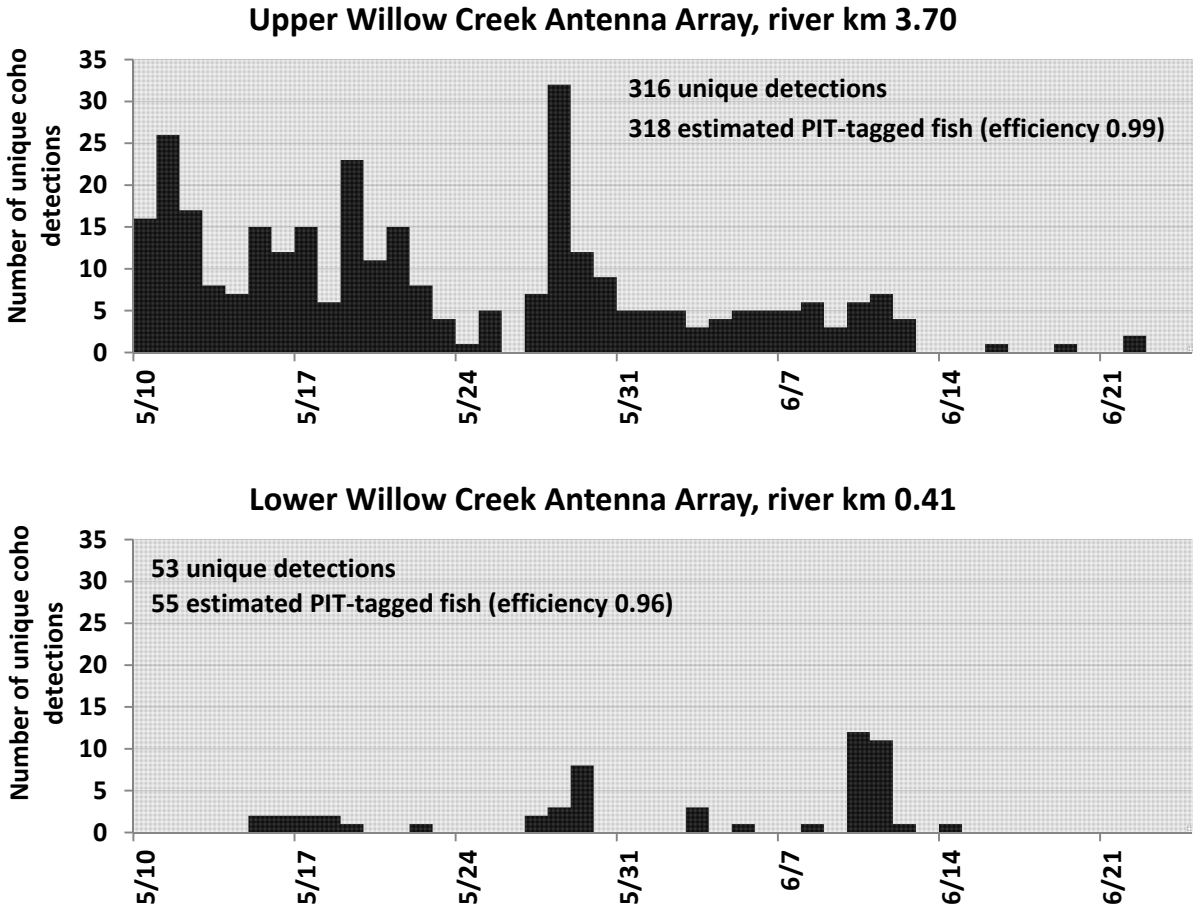
The upper Willow Creek antenna array and smolt trap (river km 3.69/3.70) were placed near a change in stream habitat. Above this site, the stream consists of pool/riffle habitat characteristic of typical coho salmon spawning and summer rearing habitat. Below the site, the stream becomes very low gradient with small, multi-threaded channels. The lowest reaches become inundated during high flow events when the Russian River backs up into Willow Creek, potentially providing suitable overwinter rearing habitat for juvenile coho salmon. To explore the question of whether juvenile coho used the lower reaches of Willow Creek during the winter of 2012-2013, we examined the detection histories of a subset of PIT-tagged coho that were documented leaving lower Willow Creek during the spring smolt migration window of 2013. Of 523 PIT-tagged coho that were detected on the lower antenna arrays between March 1 and mid-June, 58% (364) of them had previously been detected moving downstream past the upper antenna array prior to March 1 (Graph 11), suggesting that they overwintered downstream of the upper antenna array, 38% (234) were detected on or after March 1, suggesting that they overwintered above the upper antenna array, and 4% (25) were not previously detected on the upper antenna array (Graph 11).



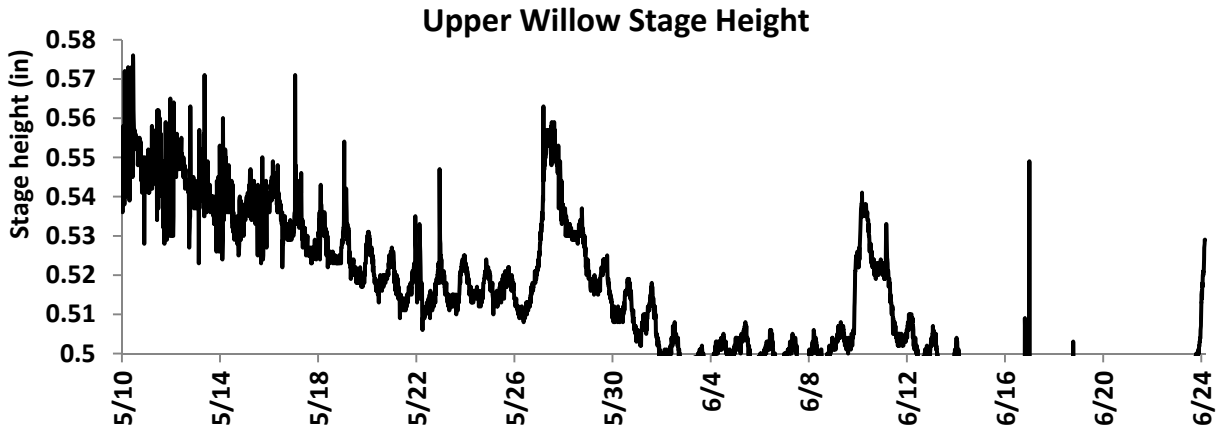
Graph 11. PIT tag detection histories of PIT-tagged coho smolts migrating past the lower Willow Creek antenna array during the spring of 2013. Shaded background represents days that the antennas were in operation.

3.6 Coho Salmon Smolt Passage Through Lower Willow During Late Spring

From May 10, 2013 through June 24, 2013 (last six weeks of the smolt migration period), a channel-spanning flat-plate antenna array was installed and operated at river km 0.41, allowing estimation of the total number of smolts migrating past both the upper and lower antenna arrays. Of estimated 318 PIT-tagged coho smolts that moved downstream past the upper antenna array during this window of time, 55 (17%) of them were estimated to move down past the lower array (Graph 12). Increases in PIT tag detections on the lower array appeared to coincide with two rain events as evidenced by increases in stage height on a gauge located at the upper Willow antenna array (Graph 13), suggesting that flow may have played a role in their ability to migrate between the upper and lower arrays during this time. It is not uncommon for fish passage to be compromised by low flows during the last month of the smolt migration period in Russian River tributaries (UCCE/CA Sea Grant unpublished data), and 2013 was a particularly dry year. In Mill Creek, for example, where UCCE/CA Sea Grant operates another smolt trap, migrating smolts became cut off from Dry Creek due to low flows during the third week of May. Dry spring seasons where passage becomes limited by flow as early as May, likely have a significant impact on survival of smolts. 38% of the smolts captured in the Willow Creek trap were captured between May 10 and June 24 and may have experienced limited passage between the two arrays. However, further data is necessary to understand the extent of this potential passage issue. Operation of year-round, channel-spanning antenna arrays at both the upper and lower Willow Creek sites for more than just a six-week period will provide further insight into potential passage issues through lower Willow Creek.



Graph 12. Detections of PIT-tagged moving downstream past the upper and lower antenna arrays between May 10 and June 24, 2013. Shaded background represents days that the antennas were in operation. Note that all unique PIT-tag detections are shown for the upper array, whereas for the lower array, only unique individuals that were previously detected on the upper array are shown.



Graph 13. Hourly stage height recordings from a continuous stage height recorded located on Willow Creek, immediately downstream of the upper antenna array between May 10 and June 24, 2013.

3.7 Detections of Willow Creek Released Coho Salmon in other Location in the Russian River Watershed.

PIT-tagged coho released in Willow Creek were also detected at other locations monitored by UCCE/CA Sea Grant in the lower Russian River watershed (Figure 4). Between mid-November, 2012 and mid-June 2013, 83 unique PIT-tagged Willow Creek coho were detected at the Duncans Mills antenna array (Graph 14); nine were detected at the Dutch Bill antenna array (Graph 15); and 14 were detected at the Green Valley antenna array (Graph 16). In addition, the Sonoma County Water Agency captured a Willow Creek released coho smolt in a smolt trap it operates on Mark West Creek during the spring of 2013 (Figure 4). The majority of the detections occurred during high flow events in late November and late December (Graph 17). All antenna detection sites did not span the channel width and/or were not paired arrays, therefore, it is likely that not all Willow Creek released coho salmon that passed over each site were detected, and the numbers reported should be considered the minimum number of fish that passed over each location.

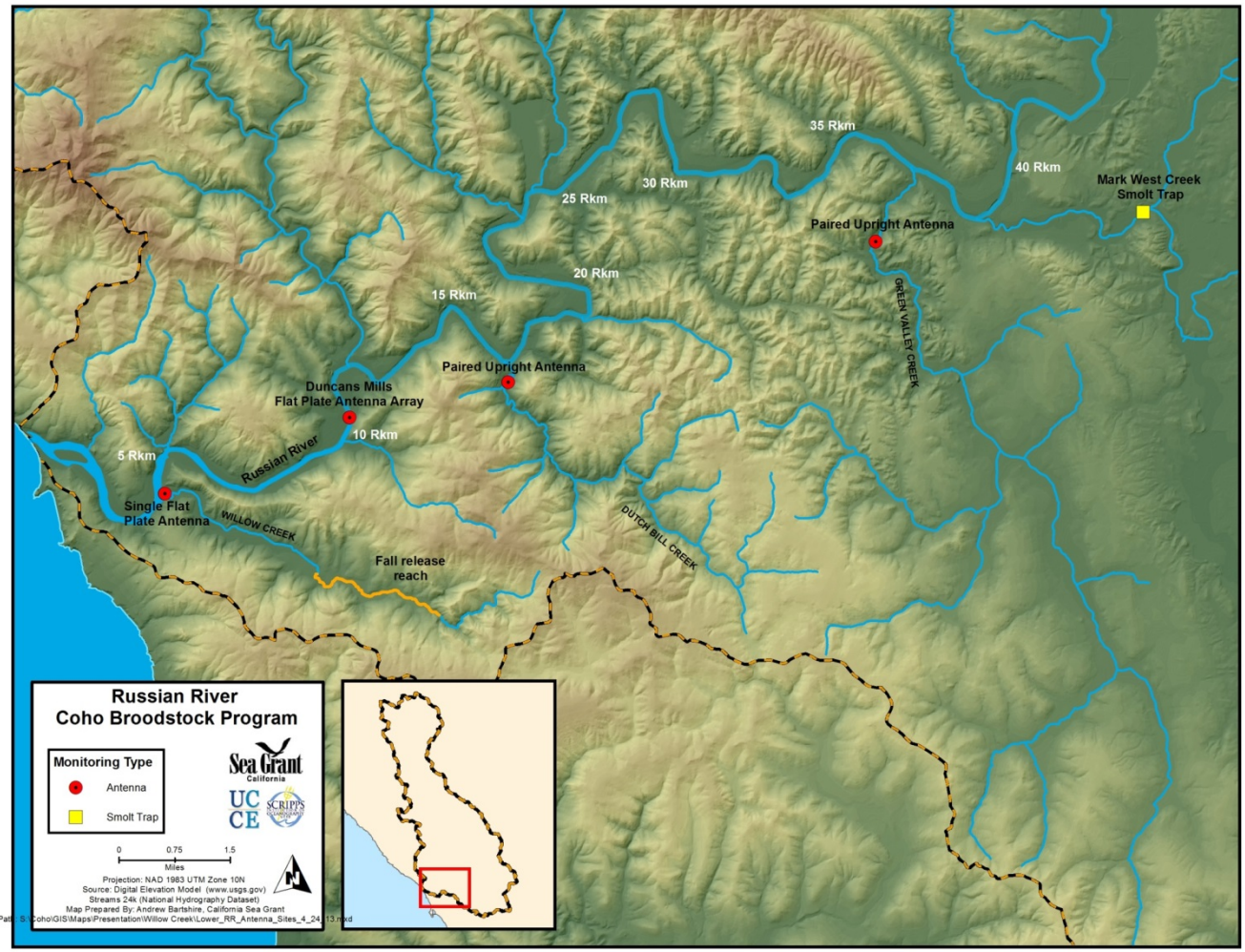


Figure 4. Map of Lower Russian River PIT tag Antenna Arrays Operated by UCCE/CA Sea Grant and/or the Sonoma County Water Agency During the Winter of 2012-2013.

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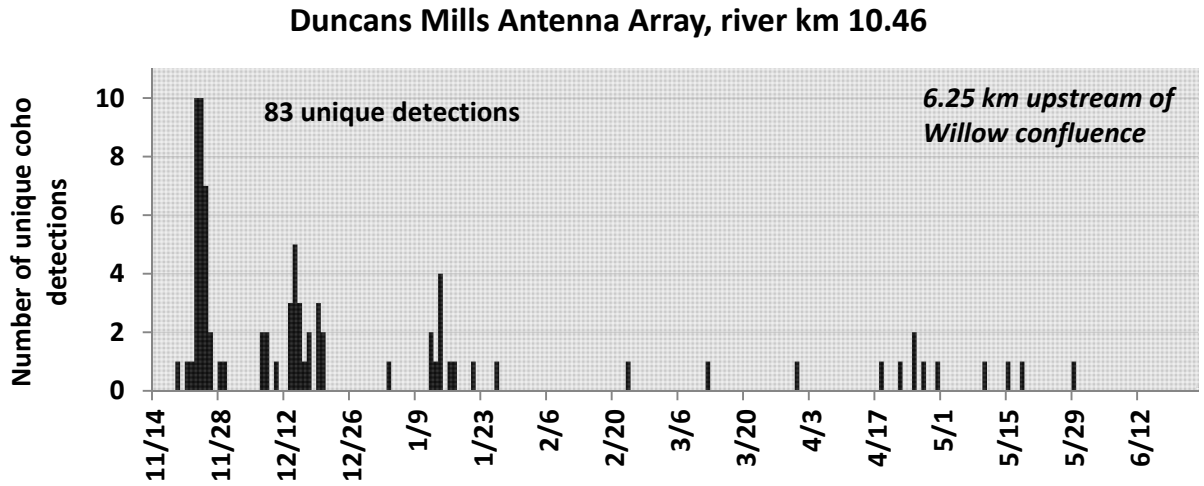
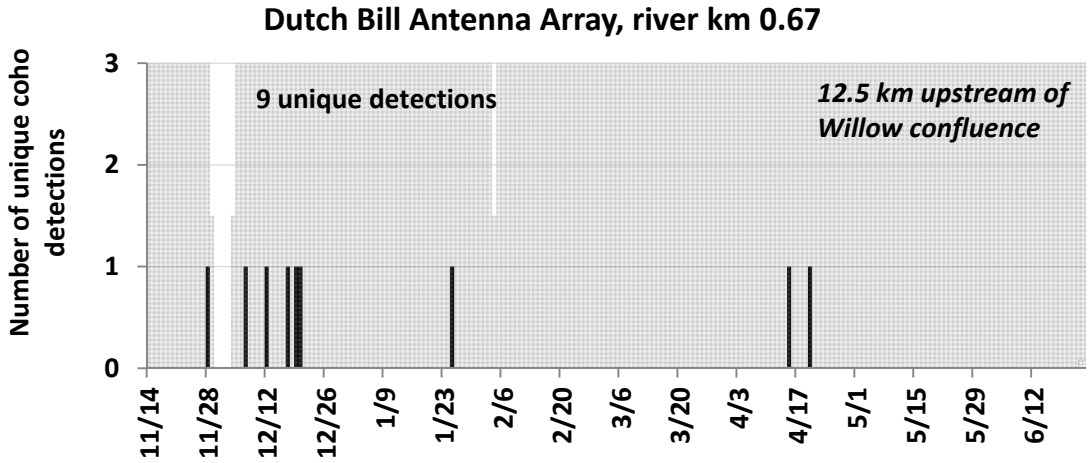
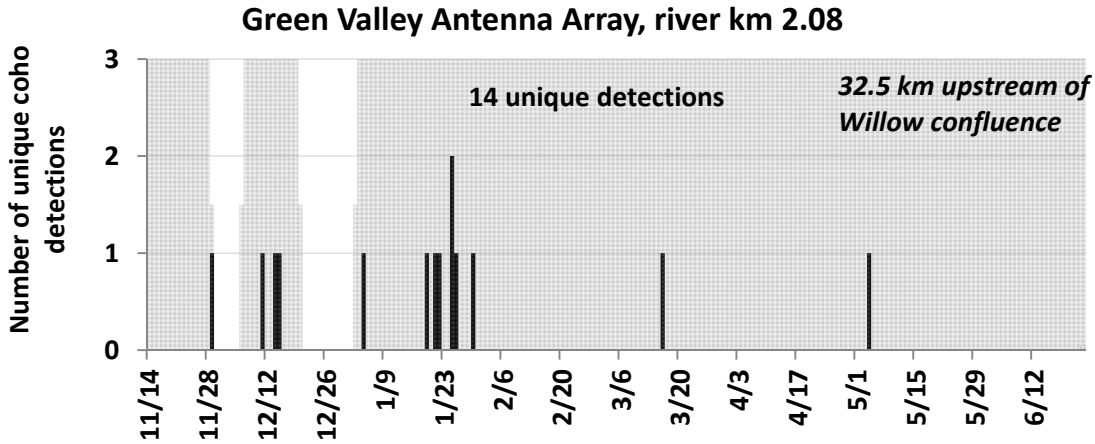


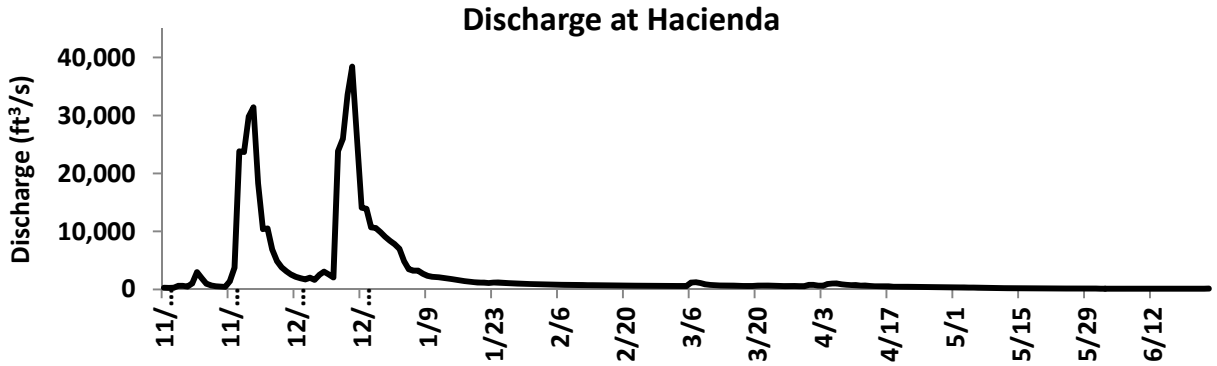
Graph 14. Unique Willow Creek released PIT-tagged coho detected at the Duncans Mills antenna array between November 14, 2012 and June 24, 2013. Shaded background represents days that the antennas were in operation.



Graph 15. Unique Willow Creek released PIT-tagged coho detected at the Dutch Bill Creek antenna array between November 14, 2012 and June 24, 2013. Shaded background represents days that the antennas were in operation.



Graph 16. Unique Willow Creek released PIT-tagged coho detected at the Green Valley Creek antenna array between November 14, 2012 and June 24, 2013. Shaded background represents days that the antennas were in operation.



Graph 17. Stream discharge at USGS 11467000 Russian River, Guerneville, CA.

3.8 Evidence of Coho Salmon from other Russian River Tributaries Entering Willow Creek

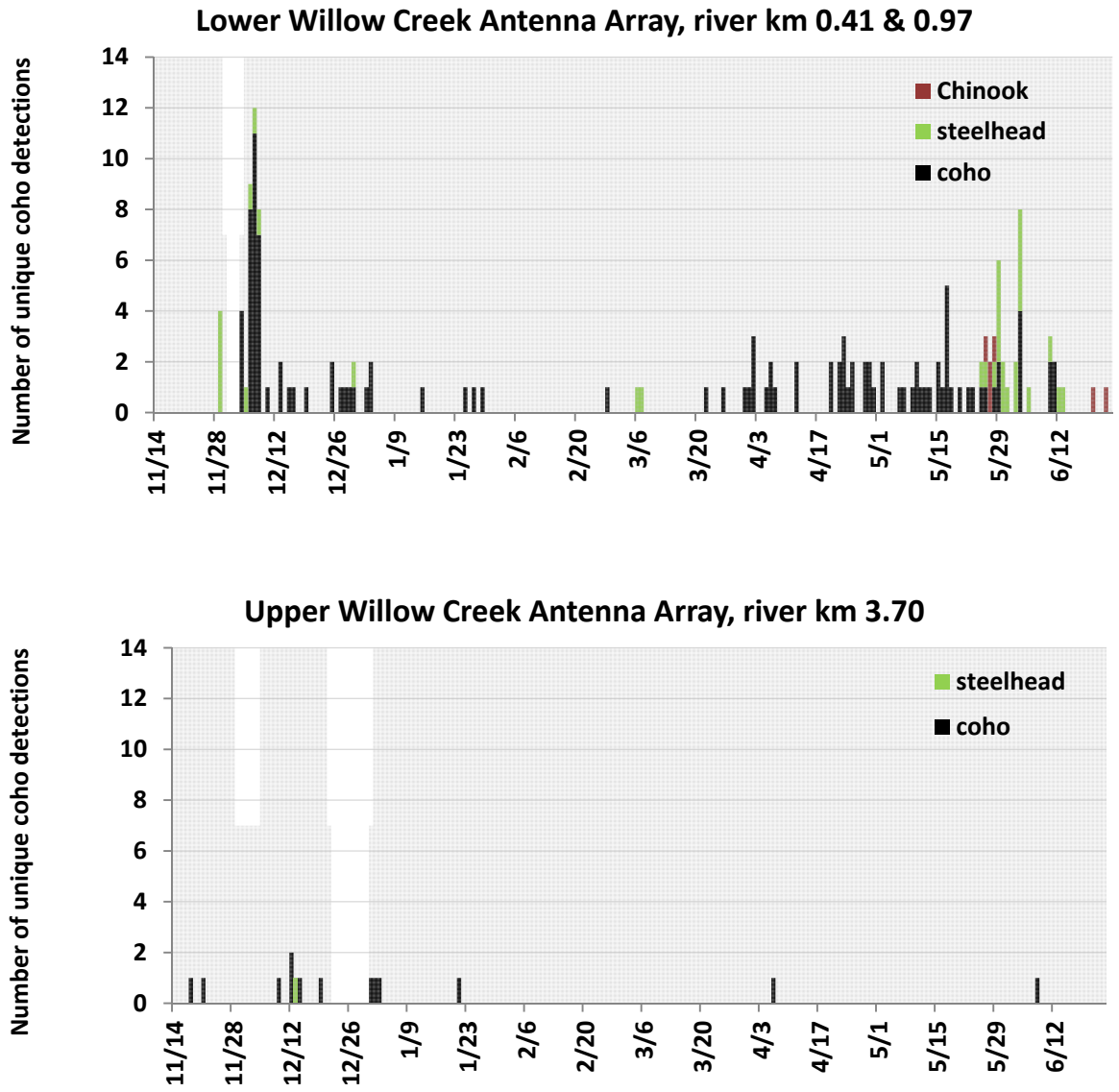
PIT-tagged coho salmon, steelhead, and Chinook salmon released or PIT-tagged in other areas of the Russian River watershed were detected in Willow Creek between November 14, 2012 and June 24, 2013. Thirteen unique PIT-tagged coho were detected at the upper antenna array and 113 at the lower antenna array (Table 4). These fish originate from a number of broodstock releases (i.e., Dutch Bill, Green Valley, East Austin tributaries, etc.). One PIT-tagged steelhead was detected at the upper array, and 32 steelhead were detected at the lower array, and six Chinook salmon were detected at the lower array (Table 5). There were two peaks in timing of detections; one during high flow events in November/December, and a second during the spring smolt migration period (Graph 18).

Table 4. Coho Salmon Released into Russian River Tributaries and Later Detected on Willow Creek Antenna Arrays during Winter/Spring 2012-2013.

Coho Release Year (hatch year 2012)	Release Tributary	Release Season	Lower Willow	Upper Willow
2012	Black Rock Creek	spring	4	0
	Devil Creek	spring	2	1
	Dutch Bill Creek	spring	19	3
	Dutch Bill Creek	fall	56	6
	Gilliam Creek	spring	9	1
	Gray Creek	spring	11	0
	Green Valley Creek	spring	0	1
	Green Valley Creek	fall	1	0
	Thompson Creek	spring	4	1
2013	Dry Creek	smolt	4	0
	Dutch Bill Creek	smolt	1	0
	Green Valley Creek	smolt	1	0
	Mill Creek	smolt	1	0
Totals:			**113**	**13**

Table 5. Steelhead and Chinook salmon PIT tagged at Sonoma County Water Agency Smolt Traps and Later Detected on Willow Creek antenna arrays during winter/spring 2012-2013

Species/Tag Site	Lower Willow	Upper Willow
Steelhead Austin trap	26	0
Steelhead Dry Creek trap	1	0
Steelhead estuary seining	5	1
Chinook Dry Creek trap	6	0
Total Steelhead:	**32**	**1**
Total Chinook:	**6**	**0**



Graph 18. Unique PIT tag detections of hatchery coho salmon released into other Russian River tributaries, and steelhead and Chinook salmon tagged at Sonoma County Water Agency smolt traps in other parts of the Russian River watershed during winter/spring 2012-2013. Shaded background represents days that the antennas were in operation.

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University of California Cooperative Extension (UCCE). 2012. UCCE Russian River Coho Broodstock Program Spawner Survey Protocol, Winter 2012-2013.

Table 6. Adult spawner/redd and juvenile snorkel survey details.

Date	Reach(es)	Observations
Winter Spawning Surveys 2011		
February (multiple surveys)	2nd bridge to well upstream of Hunter's Camp	Two surveys following storm events during peak steelhead migration; only one small unknown fish observed
23 March	3rd Bridge to confluence with first tributary	No fish observed
Summer Snorkel Surveys 2011		
13 September	Partial survey of 2nd to 3rd Bridge; 3rd Bridge to Hunter's Camp	Surveyed select pools in between 2nd and 3rd bridge; water quality fairly poor with limited visibility, one 2+ steelhead and stickleback observed. Survey from 3rd bridge to Hunter's camp, very few steelhead yoy and parr present; Other species observed included sculpin and threespine stickleback.
14 September	Hunter's Camp to below forks	A number of steelhead yoy and parr/residents observed throughout reach. Other species observed included prickly sculpin and signal crayfish.
Winter Spawning Surveys 2011-2012		
20 December	-	Survey attempt; conditions unsuitable
2 February	3rd Bridge to 500' upstream of confluence with first tributary	Unknown adult salmonid, 4 coho salmon jacks, and 2 unknown jacks between 3rd Bridge and Hunter's Camp; Adult male steelhead well upstream of Hunter's Camp; unknown adult salmonid near pull out; No redds observed
14 February	3rd Bridge to confluence with first tributary	Unknown female adult salmonid on a redd; possible redd; finished redd.
1 March	Pomo Campground tributary from parking lot to limits of anadromy; parking lot downstream several hundred feet (to dense thickets)	No fish or redds observed
5 March	3rd Bridge to bedrock falls above forks	Unknown jack; No redds observed
27 March	-	Survey attempt; conditions unsuitable
2 April	-	Survey attempt; conditions unsuitable
9 April	3rd Bridge to car park	2 pairs of small steelhead observed; possible redd sites?; very few fish otherwise, large schools of coho salmon absent

Date	Reach(es)	Observations
Summer Snorkel Surveys 2012		
6 August	Below 2nd Bridge	Surveyed select pools in historic channel (north side) and main channel (south side). Several parr size salmonids observed from land; no salmonids observed during dives. Water quality fairly poor with limited visibility. Sculpin, stickleback, rough skinned-newt noted throughout survey reach.
5 September	3rd Bridge to Hunter's Camp	Steelhead yoy and parr present throughout reach; Other species observed included sculpin, stickleback, California giant salamander, signal crayfish, California red-legged frog, and 3 coho smolts holdovers with adipose fin clips, a possible pikeminnow, and California red-legged frog.
13 September	Hunter's Camp to first tributary; First tributary upstream 400' to barrier	Steelhead yoy and parr present throughout reach; Other species observed included sculpin, stickleback, signal crayfish, and California giant salamander.
17 September	First tributary to upstream of bedrock barrier	Steelhead yoy and parr present throughout reach; Other species observed included signal crayfish and California giant salamander.
Winter Spawning Surveys 2012-2013		
11 December	3rd Bridge to falls and both tributaries	No adult fish observed; One possible spawning location noted above forks.
20 December	Hunter's Camp to forks	No adult fish or redds observed.
3 January	3rd bridge to car park	Carcass observed at bottom of pool, salmon eggs on creek bank, river otter scat noted nearby. No redds observed.
17 January	3rd bridge to Hunter's Camp	Adult steelhead; Steelhead redd observed
23 January	3rd bridge to pull out	Two adult steelhead; one includes individual noted previous week
7 February	3rd bridge to pull out	Salmonid carcass observed
4 March	3rd Bridge to pull out	No adult fish or redds observed
8 April	3rd Bridge to pull out	Small resident (2+) or steelhead jacks noted as several locations