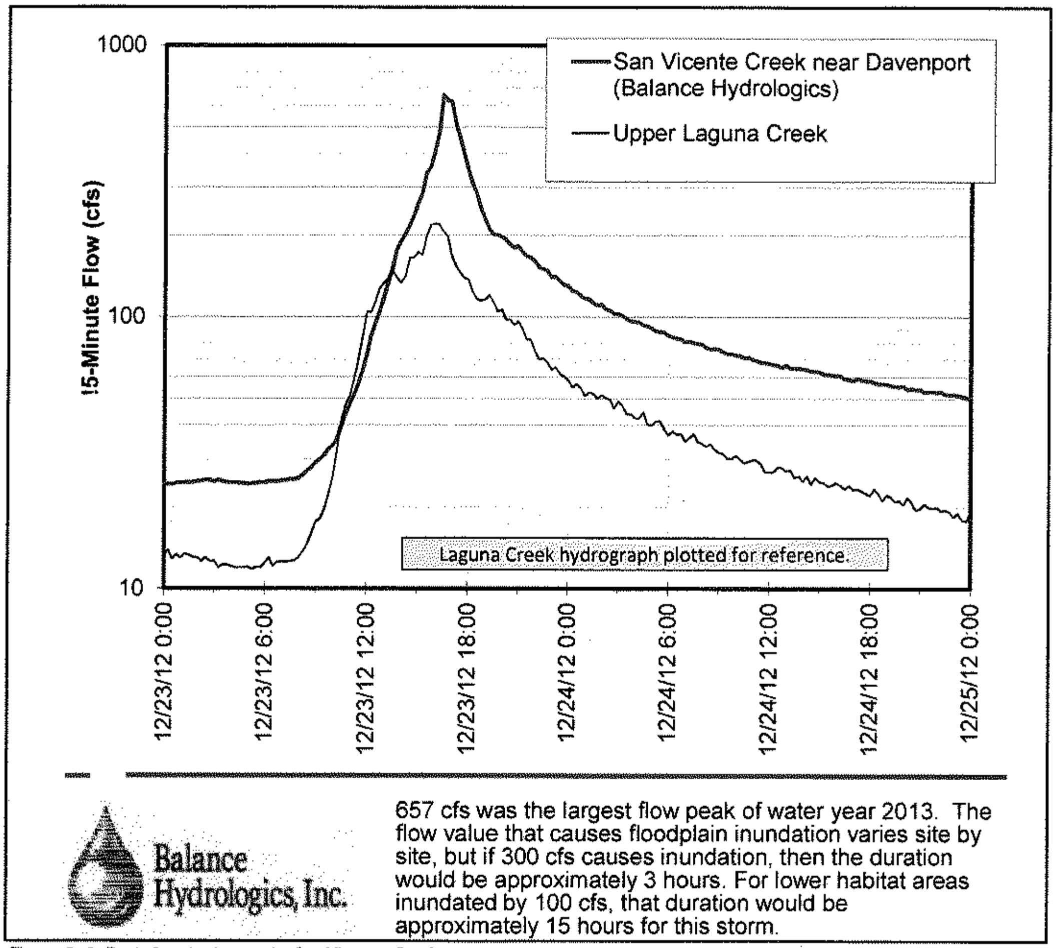


Figure 3-9. Peak flow hydrograph: San Vicente Creek, water year 2013

However because San Vicente is a small and steep watershed, flood durations last only for short periods, so many complex habitat features may best be viewed as short-term high-flow refuge unless they are well connected to the creek at low flow.

Floodplain-to-Creek Connectivity Findings

» Overall, the degree of floodplain connectivity does not seem to be closely associated with specific reaches below Mill Creek; the good and marginal sites occurred only in reaches 2 and 4, although more sites would need to be surveyed to make that a general conclusion. Also, we do not expect that notable floodplains would be present above Mill Creek, in both the San Vicente mainstem and Mill Creek, because of the steep canyon morphology.

» Floodplain connectivity seems to vary quite locally. Some well-connected locations only last for approximately 100 feet or less longitudinally, and can also transition quickly from poorly connected to marginally connected. We did not observe long longitudinal stretches of well-connected floodplain, although we did observe long longitudinal stretches of poorly-connected floodplain.

» Over time, with less human disturbance, we expect floodplain connectivity to gradually (or with occasional large changes during the largest flows) improve site by site as wood jams and floods erode creek banks and form new floodplains. This process can be accelerated with restoration projects that lower floodplains (or raise the creek bed) and increase channel complexity.

» We found a small number of complex floodplain and complex habitat features. Complex floodplains and channels provide more high-flow refuge for fish, as well as more trapping capacity for large wood and sorted patches of sediment. Complex features that connect to the creek or are lower than the rest of the floodplain would have longer periods of inundation and would be more beneficial to fish. Strategically adding large wood (or wood structures) can improve and maintain complex habitat features by focusing high-velocity storm flow to locally scour sediment.

FINDINGS

A. Although the degree of sediment sources in San Vicente Creek are low relative to other Santa Cruz Mountain streams, on-going and planned road-drainage improvements should provide additional reductions of fine sediment to salmonid habitats.

B. Because the quarry appears to function as a sink for upper watershed coarse sediment, and because dynamics of sediment moving through bedrock tunnels in and near the quarry is poorly understood, additional study may be required to better understand sediment dynamics through the quarry, such as repeat surveys of sediment deposits in the quarry, or paired bedload measurements above and below the quarry tunnel over a range of events. However, access to these locations is difficult and may be infeasible during wet conditions.

C. There is potential to reduce fine sediment in the creek system by repairing, stabilizing, and revegetating some of fine sediment sources identified in this study. Steep and remote terrain in may be the most limiting factor for implementing channel restoration or mitigation measures. Alternatively, fine sediment can be address through more passive approaches. This may include restoration elements in downstream reaches that encourage overbank deposition.

D. Introduction of instream wood in Reach 2 seems to be trapping and storing gravel-sized sediment, but the cumulative and long-term effects of introduced wood on reducing fines to downstream reaches is unknown. This approach of adding large wood could be expanded to a larger-scale pilot study to evaluate its effect on reducing fine sediment to the stream.

E. Gravels comprised a range between 15 percent and 46 percent of riffles in San Vicente Creek, which may be considered low-to-moderate abundance for salmonids. Gravel augmentation has been suggested as a possibility for enhancing gravel abundance in San Vicente Creek; however, our assessment cannot conclude whether such efforts are feasible or needed. We suggest that a separate study be undertaken to review the feasibility of gravel augmentation for the lower reaches of San Vicente Creek.

F. Fines less than 8mm comprised between ten and 45 percent of 12 riffles examined at part of this assessment. Coho typically have lower rates of survivability when riffles include 30 percent or more of fines. While only two riffles exceeded 30 percent fines, the average percent of fines approached 25 percent and suggests that fines may be a limiting factor in salmonid spawning habitat. We suggest that a combined effort of fine sediment source reductions and/or floodplain enhancement are undertaken to minimize additional fines.

G. Measurements for embeddedness suggest San Vicente Creek exhibits a moderate level of embeddedness (22 percent across all riffles), but only slightly less than value considered as detrimental by the CDFW (25 percent). We recommend that efforts to reduce fine sediment to San Vicente Creek should be sought to maintain or improve substrate conditions.

H. Floodplain re-activation projects have potential in the four reaches downstream of the Mill Creek confluence. Within those reaches, locations need to be evaluated on a site-specific basis because there is frequent variability over short distance. Avoiding reach 1 may be desired due to the potential for backwatering and resulting sedimentation due to potential clogging of the Highway 1 tunnel during high flows (as occurred during 1998).

I. Because we did not find long stretches of well-connected floodplains, restoration efforts could focus on connecting short sections of well-connected floodplain that are close to each other. This could be designed by creating low-elevation backwater channels instead of- or in addition to- lowering large swathes of floodplain.

J. Improving floodplain connectivity can be performed by lowering the floodplain (such as by mechanical removal of vegetation and soil), or by raising the channel bed of the creek (such as by adding large wood that fully spans the channel). Locations where the floodplain has marginal connectivity should be considered as candidates for raising the bed of the channel with large wood (probably limited to half the diameter of available wood). Projects that use large wood that fully crosses the creek channel will also likely help retain gravel-sized sediment.

K. Because there are limited locations with good creek-to-floodplain connectivity, natural areas of good floodplain-to-creek connectivity (sites 3 and 7) should be used as analogs for designing complex floodplain re-activation projects. These sites have examples of complex habitat features such as low floodplains, backwater channels, undercut banks, and creek wood.

Chapter 4: Fisheries

OBJECTIVES

During a 2003 smolt outmigration study conducted in the lower San Vicente Creek watershed (ESA, 2003), over 1,000 coho salmon smolts were documented migrating to the ocean. However, by the time RCD submitted a grant application for the preparation of the *San Vicente Creek Watershed Restoration Plan for Salmonid Recovery* in early 2011, coho salmon populations throughout the Central California Coast (CCC) Evolutionarily Significant Unit (ESU) of the species had plummeted and it was unclear whether a self-sustaining population of coho salmon remained within the watershed. Consequently, RCD initially proposed to conduct a comprehensive, life-stage based assessment of coho salmon presence and distribution within the watershed, including spawner surveys, juvenile distribution surveys, and smolt outmigration surveys. Shortly after grant application submittal, however, both federal and State fisheries agencies began to direct significant attention and resources toward coho salmon extinction prevention and recovery in this small but productive watershed, initiating a comprehensive broodstock reintroduction and evaluation project, including extensive juvenile distribution and annual spawner surveys. As such, the goal of the fisheries assessment shifted from an independent species presence/absence assessment to collaborative support of ongoing NMFS/NOAA and CDFW efforts.

The three main objectives of the fisheries assessment were to: a) collect smolt outmigration data related to population size and composition, while also collecting comparative data on survival of different broodstock release life stages as part of long-term research being conducted by NOAA's Southwest Fisheries Science Center (SWFSC); (b) conduct spawner surveys to determine adult spawning locations and abundances; and (c) conduct juvenile distribution surveys to identify primary rearing reaches and associated habitat elements within the watershed. To address these objectives, CDFW staff conducted spawner surveys during the 2011/2012 and 2012/2013 spawning seasons; SWFSC staff began conducting frequent snorkel and electrofishing surveys in 2011 in support of strategic releases of different life stages of broodstock coho salmon; and RCD staff, in collaboration with SWFSC staff, conducted a smolt outmigration study during the spring of 2013. In addition, CDFW staff conducted a detailed habitat typing effort in 2010.

The purpose of these assessments was to begin answering a number of questions regarding coho salmon and steelhead utilization of the watershed, and to identify potential limiting factors to salmonid survival and productivity. It should be noted, however, that assessments conducted under this grant project are part of a larger long-term study, and answers to some of these questions will not be available for some time.

- » Where within the watershed do adult salmonids spawn? Are suitable spawning sites limiting salmonid populations? Do wild (i.e., non-broodstock) coho salmon adults still return to spawn in San Vicente Creek?
- » Where within the watershed do juvenile salmonids rear? Are suitable rearing sites limiting salmonid populations? What are the survival and productivity rates of different life stages of broodstock coho salmon releases?
- » What are the rates of juvenile-to-smolt survival in San Vicente Creek? What is the condition of outmigrating smolts?

This report summarizes the findings to date of these collaborative efforts. In conjunction with the findings and recommendations of the hydrology, geomorphology, large woody debris, and invasive species assessments conducted under this grant, the findings of the various fisheries assessments represent our current understanding of salmonid population and habitat conditions in the San Vicente Creek watershed and will help guide future habitat restoration and species recovery efforts.

INTRODUCTION

San Vicente Creek is a small, third order coastal stream in northern Santa Cruz County, California, supporting coho salmon (*Oncorhynchus kisutsch*) and steelhead (*Oncorhynchus mykiss).* Its headwaters are located at an elevation of approximately 2,600 feet and its main stem flows for about 9.3 miles before emptying into the Pacific Ocean just south of the town of Davenport. The 11.1 square mile watershed also includes 11.3 miles of tributary streams, the most significant of which is Mill Creek (CDFG, 1998). San Vicente Creek does not have a lagoon because the mouth of the creek was diverted through a 245-foot long manmade bedrock tunnel when railroad tracks were constructed over the creek in 1906 (ESA, 2001) and the presumably historic lagoon was filled in by the railroad grade. Approximately 65 feet upstream of the bedrock bore, the creek passes through a 142-foot long concrete box culvert underneath Highway 1. Depending on tidal elevations, the creek exits the tunnel either on the north side of San Vicente Beach or directly into the Pacific Ocean. Due to the lack of a sandbar, adult coho salmon and steelhead migration into the watershed is never blocked at the mouth of the creek. However, a defunct mining tunnel at stream mile 3.4 of San Vicente creek presents a permanent barrier to fish migration and thus marks the upstream extent of accessible main stem anadromous salmonid habitat. Water diversion dams located at stream miles 0.5 and 0.75 on Mill Creek prevent fish from utilizing the upper watershed of that tributary (CDFG, 1998). In addition to coho salmon and steelhead, San Vicente Creek supports populations of prickly sculpin (*Cottus asper*), coastrange sculpin (*C. aleuticus*), and threespine stickleback (*Gasterosteus aculeatus*) (ESA, 2003). A single occurrence of a non-native green sunfish (*Lepomis cyanellus*) has been documented within the watershed (ESA, 2003).

Mean annual rainfall in the watershed ranges from about 24 inches at the mouth to upwards of 60 inches in the headwaters along Empire Grade (CDFG, 1998). The geology and precipitation are such that San Vicente Creek sustains summer minimum baseflows of about 1 cubic feet per second (cfs) in nearly all years —a large flow by regional standards and a criticallyimportant attribute in restoring coho salmon and steelhead populations (Stamm et al., 2008). The hydrology and geology of the watershed are discussed in detail in chapters one and two, respectively, of this report.

Although redwood forest dominates the watershed, the lower reaches of the creek support a narrow riparian zone dominated by alders (*Alnus spp.*) and willows (*Salix spp.).* Timber harvesting, water diversions, and rural residential development occur in the upper watershed. Open pit mining historically occurred in the upper watershed, but was recently terminated. Cattle grazing and agricultural water diversions historically occurred in the lower watershed but were gradually phased out over the past decade.

History, Previous Studies or Projects

Salmonid Populations

The historic presence and abundance of salmonid populations in San Vicente Creek are fairly well documented. A newspaper article dating back to 1866 placed San Vicente Creek at the top of the county's fisheries streams:

> *"The best [trout fishing] stream probably, is the San Beicente [San Vicente], ten miles up the coast, a large creek emptying into the sea. In this stream, trout bite as rapid and as strong as in Eastern streams, and [are] even more abundant and delicious. The largest trout caught (by Mr. Begelow, the insurance agent), being over 22 inches long and weighing about four pounds. In this stream the largest average from ten to fifteen inches."* (Sentinel 1/13/1866)

In addition to steelhead trout, museum specimens of coho salmon from San Vicente Creek dating back to 1895, prior to the first known stocking of coho salmon south of San Francisco Bay, provide strong evidence that the species historically occurred in the watershed (Spence et al., 2011). However, recreational and industrial pressures on these populations were already significant at the time, as indicated by the following reports:

> *"Messrs. Tom Dakan and Rob Dudley whipped the San Vicente for trout Sunday with immense results. Eight hundred and fifty is the record they are willing to make their affidavit on, and all caught with a hook."* (Surf 6/2/1891)

> *"The San Vicente Creek, beloved of the angler and the artist, has its mouth stopped by a vast dyke, and its throat choked into a tunnel, a saloon on its border, and its bed for miles denuded of the granite cobbles and sand beds. A sawmill is swiftly cutting out the timber and dirt and debris defile the pools and clog the riffles where lurked the gamey trout."* (Surf 2/02/1906)

In 1934, CDFW staff surveyed San Vicente Creek and noted both the presence of steelhead and past steelhead stocking. Natural propagation was said to be "good in normal years" (DFG, 1953). A CDFW (DFG, 1953) report states, "...the upper portion of this creek is a beautiful trout creek."

Coho salmon occurrences in San Vicente Creek have been documented a number of times over the past three decades, including in 1981 by Harvey & Stanley Associates (1982), in 1991 by McGinnis (1991), and in 1996 by CDFW (DFG, 1998). Steelhead have consistently been documented in San Vicente Creek throughout these and more recent survey efforts. By the late 1990's, CDFW considered the San Vicente Creek coho salmon population to be near extinction (DFG, 1998). However, a smolt outmigrant study conducted for NMFS and the Coast Dairies Land Company in the spring of 2003 captured over 1,000 coho salmon smolts and over 2,000 juvenile steelhead (ESA, 2003).

Subsequent randomized snorkel surveys, performed by SWFSC staff in 2008, observed a total of 188 juvenile coho salmon in the watershed. While this is a relatively small number from a population viability perspective, it represented the highest coho salmon abundance of any sampled watershed south of San Francisco Bay at that time (NMFS, 2012). San Vicente Creek has been identified by NMFS biologists as one of the highest priority anadromous fishery creeks south of the Golden Gate (Best, pers. comm.).

CDFW staff conducted spawning surveys in San Vicente Creek (excluding Mill Creek) and other drainages in Santa Cruz and San Mateo counties during the 2011-2012 spawning season1 to estimate regional escapement and general run timing (Jankovitz, 2012). The surveys were conducted at 10 to 14 day recurrence intervals and generally followed a protocol designed for monitoring salmonids along the north coast of California outlined by Gallagher and Knechtle (2005). However, while the protocol calls for surveys of randomly selected stream reaches, mainstem San Vicente Creek was surveyed in its entirety due to ease of access, short extent of anadromy, and the importance of the system to coho salmon recovery efforts. CDFW staff observed a total of 22 live broodstock coho salmon (see discussion of the broodstock program below), four broodstock carcasses, two ocean return coho salmon of unknown hatchery origin2, and 14 coho salmon redds between January 24 to March 1, 2012 (Jankovitz, 2012). All observations were made between the mouth of San Vicente Creek and the confluence of Mill Creek. The two ocean return coho of unknown hatchery origin were observed spawning in lower San Vicente Creek on February 17, 2012 and the resulting redd was observed and measured on February 28. This was the only pair of coho known to have returned from sea and successfully spawned in the entire Santa Cruz/San Mateo survey area3 during the

1 Spawning surveys were again conducted during the 2012-2013 spawning season, but results were not available at the time of report preparation.

2 The two adult coho salmon had clipped adipose fins, indicating they were hatchery releases, but did not contain any tags identifying the hatchery from which they were released (Jankovitz, 2012).

3 The survey area consisted of 21 randomly selected sampling reaches within

season (Jankovitz, 2012). Broodstock coho salmon constructed an additional thirteen redds in San Vicente Creek during the season. In addition, CDFW staff also identified a total of 55 steelhead redds (Jankovitz, 2012).

Broodstock Program

Recognizing the impending threat of regional extirpation of coho salmon south of San Francisco Bay, NOAA's SWFSC, in collaboration with the non-profit Monterey Bay Salmon and Trout Project (MBSTP), adopted a captive rearing strategy (captive broodstock program) in 2001 to protect the genetic legacy of southern coho salmon and provide future opportunities to reestablish coho salmon in regional streams from which they have been extirpated. Until 2011, broodstock raised by the program were only released in Scott Creek, a costal stream entering the Pacific Ocean approximately three miles north of the mouth of San Vicente Creek. However, San Vicente Creek has been identified by the inter-agency Priority Action Coho Team (Recovery and Captive Rearing Technical Work Group) as a high priority site for coho salmon reintroduction in the Santa Cruz Mountains diversity stratum, and broodstock releases to San Vicente Creek were initiated by SWFSC in 2011.

Consistent with the goals of the captive broodstock program, multiple life-stages of coho salmon have been released into San Vicente Creek since 2011 (Table 4-1) and researchers at SWFSC are conducting targeted experiments to quantify the relative success of each release strategy (e.g., release location, time of year, and life-stage). Preliminary results of this effort indicate that adult broodstock fish released into San Vicente Creek successfully spawned and produced offspring in both 2012 and 2013. The subsequent planting of 4,000 and 6,000 unfed fry across multiple release sites in April 2012 and March 2013, respectively, has further augmented the juvenile (young-of-year) coho population in the basin. The release of several hundred smolts in 2011 and April 2013 were aimed at increasing subsequent returns of broodstock adults imprinted to San Vicente Creek and matured in the ocean.

Table 4-1. Outplanting of coho salmon from the NOAA captive broodstock program into San Vicente Creek, 2011-2013.

	(year)		
Life Stage	**2011**	**2012**	**2013**
Fry (unfed)	0	4,000	6,000
Parr	0	0	0
Smolt	300	0	497
Adult	0	27	19

11 coastal watersheds, as well as seven non-randomly selected reaches within two coastal watersheds (San Vicente Creek and Gazos Creek) of San Mateo and Santa Cruz counties. Specific sampling locations are provided by Jankovitz (2012).

Habitat Quality

CDFW conducted comprehensive habitat inventories of San Vicente Creek in 1996 (DFG, 1996) and 2010 (CDFW, 2013) pursuant to standard methodologies presented in the *California Salmonid Stream Habitat Restoration Manual* (Flosi et al., 1998). The primary purpose of this type of habitat inventory is to provide a watershed or drainage-wide overview of existing habitat availability and conditions, and to develop generalized recommendations for potential habitat enhancement approaches. Due to randomized subsampling used in the assessments, as well as inherent sampler bias, these habitat inventories are generally not used as a monitoring tool aimed at documenting fine scale changes over time. However, a qualitative comparison of the 1996 and 2010 assessment results does provide valuable insights into potential basin-wide changes that may have occurred over the 14-year period between the two assessments. This section provides such a comparison. The reader is referred to the *California Salmonid Stream Habitat Restoration Manual* (Flosi et al., 1998) for detailed descriptions of assessment methodology and habitat parameters.

In 1996, broadly defined habitat types (i.e., Level II) in San Vicente Creek occurred with a frequency of 43% pool units, 16% riffle units, 40% flatwater units, and 1% culvert units. In 2010, the frequencies of Level II habitat type occurrences were 36% pool units, 35% riffle units, 27% flatwater units, 2% culvert units. These results suggest the frequency of pool units has decreased somewhat over 14 years, which is consistent with anecdotal evidence from the assessment team over the past decade. The large discrepancy between riffle and flatwater units between the two assessments, however, is somewhat surprising. It should be noted that the correct identification of riffle and flatwater units is subject to observer error to a greater extent than other habitat units. Higher stream flows and concomitant increases in stage can inundate some riffles to the extent that they appear as flatwaters. In fact, the *California Salmonid Stream Habitat Restoration Manual* indicates that run habitats, the most common flatwater unit type, "[o]ften appear as flooded riffles." Streamflow during the 1996 assessment was measured at approximately 8 cubic feet per second (cfs) while streamflow during the 2010 assessment was 6 cfs. It is therefore likely that at least some habitat units identified as flatwater during the 1996 assessment were identified as riffles during the 2010 assessment. Lastly, the discrepancy between culvert units between the two assessments is minor and likely a reflection of rounding effects. The assessment team is not aware of any new culverts having been constructed in the lower San Vicente Creek watershed during the past decade.

In 1996, fourteen individual Level IV habitat types were identified. Based on percent occurrence, the most frequent habitat types were mid-channel pool units (28%), step runs (28%), and low gradient riffles (12%). Based on percent total stream length, step runs comprised 70%, mid-channel pools 10%, and runs 5% in 1996. In 2010, a total of eighteen Level IV habitat types were identified. The most frequent habitat types by percent occurrence were low gradient riffle units (19%), run units (19%), and mid-channel pool units (15%). Based on percent total length, there were 21% run units, 18% low gradient riffle units, 16% high gradient riffle units. These results again suggest an overall reduction in pool habitat units, both in terms of frequency of occurrence and percent total stream length, between 1996 and 2010.

A total of 70 individual pool units were identified in 1996 under a random subsampling protocol (i.e., not all pools were quantified), with main channel pools being the most abundant (64%) pool habitat unit type, comprising 69% of the total length of pools. The 2010 assessment included quantification of all pool units and identified a total of 123 individual pools, with scour pools as the most frequently encountered at 53%, comprising 51% of the total length of all pools. Due to the different sampling intensities used for the two assessments, these numbers are not directly comparable.

Pool quality for salmonids increases with depth, particularly if instream shelter is present within the pool. Twenty-one of the 70 pools (30%) identified in 1996 had a residual depth of three feet or greater, while only 13 of the 123 pools (11%) had a residual depth of three feet or greater in 2010. Residual pool depth is a measure that is independent of streamflow or stage, and therefore provides a useful comparison tool. The residual pool depth data for 1996 and 2010 appear to indicate that pool depths have decreased considerably over 14 years. Coho salmon are known to prefer deep pools and relatively slow water velocities while steelhead generally reside in the more shallow and fast-flowing areas of a channel (e.g., Roni, 2002). As such, the apparent loss of deep pool habitat availability in San Vicente Creek has likely affected coho salmon disproportionately.

The depth of cobble embeddedness was estimated at pool tail-outs. This habitat parameter is rated on a scale of 1 to 5, with a value of 1 indicative of the best spawning conditions and a value of 4 representing the worst. A value of 5 is assigned to tail-outs that are deemed unsuited for spawning due to inappropriate substrate such as bedrock, log sills, boulders, or other such features. Of the 70 pool tail-outs measured in 1996, one had a value of 1 (1%), 12 had a value of 2 (17%), 51 had a value of 3 (73%), one had a value of 4 (1%), and five had a value of 5 (7%). Of the 123 pool tail-outs measured in 2010, 13 had a value of 1 (11%), 78 had a value of 2 (63%), 8 had a value of 3 (7%), none had a value of 4, and 24 had a value of 5 (20%). As such, a total of 74% of measured pool tail-outs had embeddedness ratings (1 or 2) generally considered suitable for salmonid spawning in 2010, while only 18% of tail-outs contained embeddedness levels suitable for spawning in 1996. Based on this analysis alone, fine sediment levels in San Vicente Creek may have decreased over time. This observation is consistent with the results of a sediment source inventory conducted for this report (chapter 2) that "identified very few active sediment sources that currently may impair spawning/rearing habitat."

Available instream cover was evaluated using a standard shelter rating for each habitat unit. The proportion of each habitat unit that is influenced by some type of shelter is estimated as a percentage of the total surface area of the unit, and a standard qualitative shelter value of 0 (none), 1 (low), 2 (medium), or 3 (high) is assigned according to the complexity of the cover. The shelter rating is calculated for each fully-described habitat unit by multiplying shelter value and percent cover. Thus, shelter ratings can range from 0-300 and are expressed as mean values by habitat types within a stream. A pool shelter rating of approximately 100 is desirable for salmonids. For San Vicente Creek, the mean shelter ratings for riffle and flatwater habitat types were very low (ratings of 10 or less) and similar to each other in 1996 and 2010. However, the mean shelter rating value for pools increased from 12 in 1996 to 35 in 2010. The dominant overall cover type was boulders during both assessment years. Within pools, the dominant cover types were root masses and boulders in 1996, but terrestrial vegetation and small woody debris in 2010. More importantly, large woody debris (LWD) accounted for only 7% of measured pool cover in 1996, but for 16% in 2010. These values may be indicative of marginal increases in large woody debris (LWD) loading in San Vicente Creek over the past 14 years. A detailed discussion of current LWD loading and recruitment potential is provided in chapter 5 of this report.

Channel substrate size suitability for salmonid spawning was evaluated differently in 1996 (sampled in low gradient riffles) and 2010 (sampled in pool tail-outs). During the former assessment, 100% of low gradient riffles contained large cobble as the dominant substrate size, which is generally considered unsuitable for spawning. In 2010, gravel substrate was dominant in 34% of pool tail-outs and small cobble substrate was dominant in 31% of pool tail-outs in 2010. Gravel and small cobble substrates are generally considered to provide suitable spawning conditions. No comparative conclusions can be drawn from the data presented for the two assessments, other than a potential indication that low gradient riffles in San Vicente Creek may not provide suitable spawning conditions (at least in 1996) while the majority of pool tail-outs appear to provide spawning opportunities (at least in 2010).

The mean percent canopy density for the surveyed length of San Vicente Creek was 87% in 1996 and 92% in 2010. In 1996, 75% of canopy cover was provided by hardwood trees, 12% by conifers, and 13% of the survey reach was classified as open (i.e., no canopy cover). In 2010, 78% of canopy cover was provided by hardwood trees, 14% by conifers, and only 8% of the survey reach was classified as open. Similar trends were observed in the percentage of vegetated streambanks, with 73% and 76% of the right and left banks, respectively, vegetated in 1996; and 77% and 80% of the right and left banks, respectively, vegetated in 2010. Although individual canopy cover and bank vegetation values for 1996 and 2010 are very similar, the data suggest that a gradual trend toward increased canopy cover has occurred since 1996.

In conclusion, the two habitat inventories indicate that pool habitat availability and quality has been decreasing while riparian canopy cover and LWD loading has been increasing slightly. Suitable spawning habitat is generally available in most pool tail-outs, and embeddedness ratings are relatively low. As depicted in Figure 4.7, coho salmon redds observed during the 2001-2012 spawner surveys were generally concentrated in reaches containing multiple pools.

METHODOLOGY

Smolt Outmigration

An outmigrant trap was installed in San Vicente Creek on March 1, 2013 and operated daily through June 15, 2013 to assess current population size, size of fish, migration timing, and freshwater survival. The outmigrant trap was installed immediately downstream of a boulder weir associated with the inlet structure for the Lower San Vicente Pond restoration site. This site was selected based on ease of access and security. The trapping site is located approximately 775 feet upstream of the Highway 1 culvert. Thus, outmigrating smolts from a small portion of the overall watershed locate downstream of the trap were not sampled in this study.

Study methodologies were consistent with the *California Coastal Salmonid Monitoring Plan* (CMP) as presented in Fish Bulletin 180 (DFG, 2011), but expanded upon to collect additional data in support of ongoing SWFSC broodstock reintroduction and research efforts. The trap consisted of a 2-foot diameter, 7-ring, 2-chamber hoop net with a 0.25-inch mesh size. Seine wings attached to both sides of the trap opening were used in an attempt to block the entire wetted width of the channel to achieve 100% trapping efficiency. Due to the design of the trap with seine side wings, upstream migration of adult salmonids was not impeded as these individuals were able to easily swim over the top of the seine, as was observed on two occasions. The trap was operated 24 hours per day, 7 days per week and checked daily, at a minimum. Trapped fish were transferred into a 20-gallon holding bucket filled with stream water. All non-salmonid species were returned to the stream. Coho salmon and steelhead were anesthetized in a short MS-222 bath. Forklengths of juvenile salmonids were recorded to the nearest millimeter using standard plastic rulers. Wet weights were measured to the nearest 0.1 grams using an Ohaus Scout II electronic scale with a 400-gram capacity. Evidence of fish diseases (e.g., black spot disease) and other noteworthy observations were also recorded. Adult steelhead captured in the trap were estimated for length and released immediately downstream of the trap.

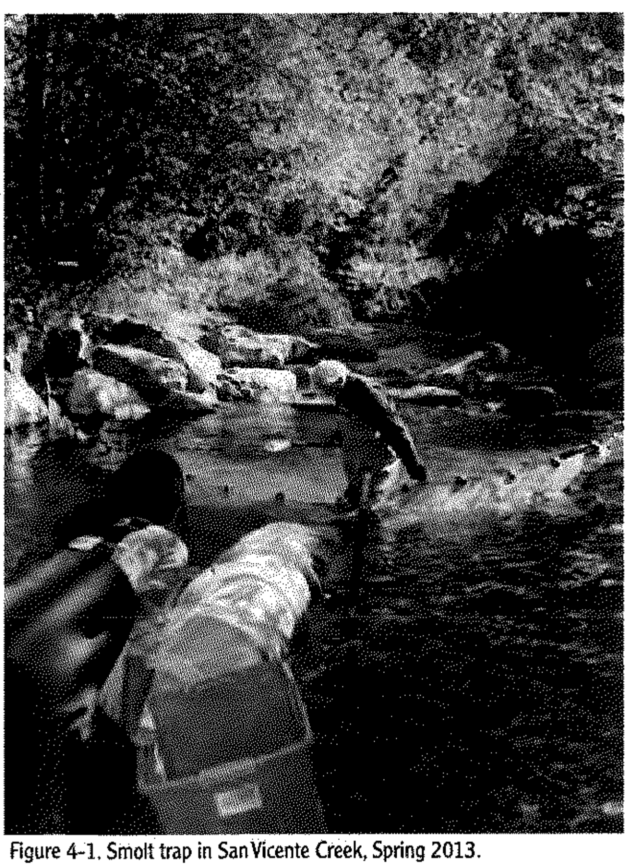


Figure 4-1. Smolt trap in San Vicente Creek, Spring 2013.

All juvenile salmonids were scanned for passive integrated transponder (PIT) tags using a Biomark 601 handheld reader, and all PIT tag codes were recorded. On April 23, 2013, SWFSC staff released 497 broodstock coho salmon smolts fitted with coded wire tags (CWT) in San Vicente Creek upstream of the outmigrant trap. Subsequent to this release, all captured coho salmon were also scanned for CWTs using a Northwest Marine Technology T-Wand CWT detector. Coho salmon containing a CWT were recorded and released immediately downstream of the trap without obtaining length or weight measurements.

All captured juvenile coho salmon that had not previously been tagged with a PIT tag or CWT were implanted with a 12 millimeter half duplex (HDX) PIT tag manufactured by Oregon RFID. The PIT-tagging techniques used were consistent with methodologies described by the Columbia Basin Fish and Wildlife Authority PIT Tag Steering Committee (CBFWA, 1999). The PIT tags were implanted into the body cavity between the posterior tip of the pectoral fin and the anterior point of the pelvic girdle using syringes fitted with 12-gauge veterinary-grade needles. Scale and DNA (fin-clip) samples were also collected from all previously untagged coho salmon using standard salmonid research protocols.

After handling, fish were placed into 5-gallon holding bucket containing stream water and an aerator, and allowed to recover from the anesthesia for approximately 10-20 minutes. All recovered fish were released into a deep and calm pool located approximately 50 feet downstream of the trap.

Based on guidelines presented in the CMP, trap efficiency was assessed using a simple mark-recapture protocol. SWFSC staff operated the outmigrant trap once a week (Wednesdays). Starting on April 3, 2013, NOAA staff selected a subset of all trapped fish each Wednesday for the mark-recapture study. Selected fish were issued a PIT tag (unless one was present already) and marked with a caudal fin clip for identification.

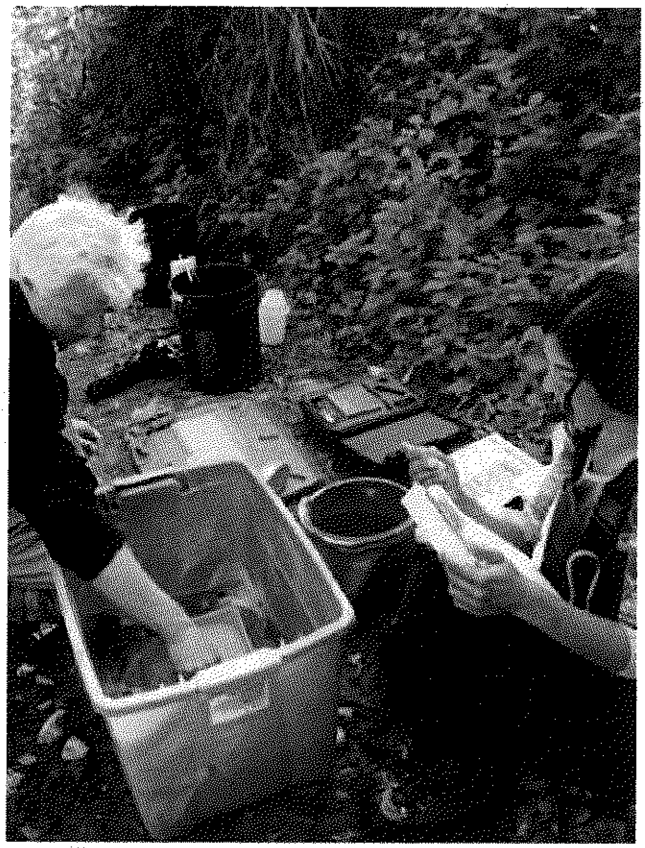


Figure 4-2. Processing of juvenile salmonids captured in San Vicente Creek, Spring 2013

Marked fish were released approximately 200 feet upstream of the outmigrant trap. PIT tag codes were used to identify and quantify marked and subsequently recaptured fish.

Outmigrant traps typically need to be removed from the stream during high flow events. However, water year 2013 proved to be a drought year along the central coast of California and no significant storm events occurred during the trapping period. As such, the trap remained in place and operational during the entire outmigrant study.

Juvenile Distribution

In July 2012, SWFSC staff conducted snorkel surveys in mainstem San Vicente Creek to document the distribution and abundance of juvenile coho salmon. The snorkel survey extended approximately 3.4 miles from the confluence with the Pacific Ocean to the quarry tunnel representing the upstream limit of anadromy. Procedurally, two snorkelers equipped with dive lights worked side-by-side to cover the width of the stream and slowly proceeded in an upstream direction. The survey was limited to pool habitat units and every pool encountered was sampled via a single pass. Based on methodologies previously employed by SWFSC staff (Spence, unpublished data), pools were defined as habitat units of at least 2.0 m^2 (21.5 ft^2) in surface area, widths at least one-half the wetted-width of the channel, and maximum depths exceeding 0.3 m (1 ft). For each pool, only the number of juvenile coho salmon was recorded; steelhead were not enumerated. Physical habitat information including location, total pool length, pool width, maximum pool depth, and pool tail depth were also recorded for each unit surveyed.

FINDINGS

Smolt Outmigration

Coho Salmon

A total of 329 juvenile coho salmon were captured in the outmigrant trap between March 2 and June 15, 2013. Of this total, 196 fish were marked with CWT, indicating that they were broodstock smolts released into the system on April 23, 2012. Of these totals, one non-CWT and three CWT coho were recaptures (see below). Furthermore, two of juvenile coho salmon captured toward the end of the trapping period were age 0+ fish (based on forklength). One of these was marked with a red visible implant elastomer (VIE) tag, indicating it was broodstock fish previously released as a fry; the other fish had no visible mark, suggesting it may have been the offspring of instream spawning. As such, the total tally of individual captured juvenile coho salmon was 130 non-CWT smolts, 193 CWT smolts, one VIE fry, and one non-VIE fry. In comparison, the 2003 trapping study (ESA, 2003) captured 703 smolts in mainstem San Vicente Creek and 319 smolts migrating from the Lower San Vicente Pond off-channel habitat feature[4], for a total of 1,022 smolts.

A total of five juvenile coho salmon were found dead upon arrival at the traps. Two of these mortalities were CWT-marked broodstock smolts and external fungus was observed on two others. Fungus infections were noted on a total of thirteen juvenile coho salmon, but twelve of these were CWT-marked broodstock smolts. Minor to moderately severe black spot (*Neascus sp.*) infestations were observed on only six captured coho salmon, none of which were broodstock CWT-marked broodstock smolts. One additional juvenile coho salmon mortality occurred during PIT-tagging.

Trap efficiency tests were inconclusive. On one hand, we felt that the positioning of the trap assured that essentially 100% of the channel width and depth were blocked by the trap and wing seines, and the absence of significant storm events enable us to operate the trap continuously without the trap being bypassed, over-topped, or removed. On the other hand, however, recapture success was low. A total of 26 coho salmon smolts (22 CWT broodstock smolts, 4 non-CWT smolts) captured in the trap were marked and released upstream. Of these, only four (three CWT broodstock smolts, one non-CWT smolt) were subsequently recaptured in the trap. These results suggest a low trap efficiency of approximately 15%. However, the recapture rate for non-broodstock smolts

4 The Lower San Vicente Pond site became hydrologically disconnected from San Vicente Creek in 2012. Therefore, no fish occupied this habitat in 2013.

was higher at 25%. Based on the fact that only 193 individual broodstock smolts of a total of 497 released by SWFSC staff were captured in the trap, survival of broodstock smolts appears to have been relatively low at approximately 39%. Alternatively, genetic cues for outmigration may have been weak in broodstock smolts. Considering that the majority (85%) of coho salmon smolts used for the trap efficiency study were broodstock smolts, the low recapture rates may be a reflection of poor survival and/or low migration rates rather than trapping inefficiencies. It is also important to note that it took an average of 22.5 days (min = 10 days; max = 36 days) for marked coho salmon to be recaptured in the trap. As such, it appears that the trapping study may have delayed outmigration through trap recognition and avoidance.

The average forklength of non-CWT coho salmon smolts was 116 mm (standard deviation, SD, ± 13 mm), and the average wet weight of non-CWT coho salmon smolts was 15.8 g (SD ± 5.4 g) (Table 4-2). The condition factor (k = 100,000 wet weight / length^3) is frequently used by fisheries biologists as an indicator of the health of a fish population, with high k values (*i.e.*, > 1.0) indicative of adequate food supplies (Moyle and Cech, 1988). The average condition factors for non-CWT coho salmon smolts was 0.98 (SD ± 0.08).

By comparison, average forklengths of coho salmon smolts captured in San Vicente Creek and Lower San Vicente Pond in 2003 were 99 mm (SD ± 10 mm) and 121 mm (SD ± 7 mm), respectively, and average wet weights were 10.1 g (SD ± 2.8 g) and 18.2 g (SD ± 2.8 g), respectively (Table 4-2). As such, average sizes of coho salmon smolts in 2013 were larger than those trapped in the mainstem in 2003, but smaller than those captured inthe off-channel habitat in 2003. Condition factors in 2003 were slightly higher at 1.02 at both trapping sites.

Steelhead

A total of 1,668 juvenile steelhead and 23 adult steelhead were captured in the creek trap during the 15-week study. Of this total, 47 juvenile steelhead were recaptures (see below). As such, the actual number of individual juvenile steelhead captured was 1,644. Smolts and presmolts (based on coloration) accounted for 407 of the total juvenile catch, with 23 of these being recaptures. As such, the actual number of individual steelhead smolts/presmolts captured was 384, or 23.4% of the total number of individual juvenile steelhead encountered in the trap. It is important to note, however, that while the use of coloration is the only available non-lethal method of distinguishing smolts from other juvenile steelhead, it is an imprecise measure of whether or not a juvenile fish will migrate to the ocean during the study period, particularly during the early part of the season when many eventual smolts captured in the trap had not yet entered the smoltification process. As such, the presented smolt numbers are likely artificially low.

A total of 18 juvenile steelhead were found dead upon arrival at the creek trap. Moderate to severe external fungus infections were noted on 10 of these mortalities. In all, fungal infections were observed on 36 juvenile steelhead and five adult steelhead. By comparison, blackspot infestations were observed on only six juveniles.

A total of 121 juvenile steelhead were marked with PIT tags and fin clips, and released upstream of the trap. Of this total, 47 juveniles (38.8%) were subsequently recaptured. Of the total number of marked fish, 51 were identified as smolts, and 23 (45.1%) of these were subsequently recaptured. It is not surprising that the rate of recapture among smolts was higher than the total juvenile recapture rate since smolts are genetically cued, and physiologically ready, to outmigrate and therefore more

Table 4-2. Coho Salmon and Steelhead Smolt Abundance, Length, Weight, and Condition in San Vicente Creek, 2013 and 2003

	(year)		
	2013	2003 (creek)	2003 (pond)
Coho (non-CWT smolts only)			
Total # trapped	130	703	319
Average forklength, mm (±SD)	116 (13)	99 (10)	121 (7)
Average wet weight, g (±SD)	15.8 (5.4)	10.1 (2.8)	18.2 ((2.8)
Average condition factor, k (±SD)	0.98 (0.08)	1.02 (0.06)	1.02 (0.05)
Steelhead (smolts/presmolts only)			
Total # trapped	384	542	34
Average forklength, mm (±SD)	164 (22)	152 (21)	163 (24)
Average wet weight, g (±SD)	42.2 (20.4)	34.3 (15.2)	42.5 (21.8)
Average condition factor, k (±SD)	0.92 (0.07)	0.93 (0.07)	0.92 (0.10)

likely to reattempt outmigration (with subsequent recapture) after being marked than non-smolts that may have initially been captured during redistribution, but did not down-migrate again after being marked. However, as discussed above, trapping efficiency qualitatively appeared to be close to 100% and the reasons for the relatively low recapture rates are not known. It is interesting to note that even though the majority (n = 27, 52.9%) of marked fish were recaptured within one day of being marked and released, the average time to recapture was 7.2 days and the maximum time was 68 days. Given the considerable delay in recapture observed in many marked fish, trap recognition and avoidance, particularly in light of the high underwater visibility (due to a lack of runoff-induced turbidity) that prevailed during most of the study period, may have been an important factor in the low number of recaptures. Predation may have also affected recapture rates.

The average forklength of steelhead smolts was 164 mm (standard deviation, SD, ± 22 mm), and the average wet weight of steelhead smolts was 42.2 g (SD ± 20.4 g) (Table 4-2). The average condition factors for steelhead smolts was 0.92 (SD ± 0.07).

By comparison, average forklengths of steelhead smolts captured in San Vicente Creek and Lower San Vicente Pond in 2003 were 152 mm (SD ± 21 mm) and 163 mm (SD ± 24 mm), respectively, and average wet weights were 34.3 g (SD ± 15.2 g) and 42.5 g (SD ± 21.8 g), respectively (Table 4-2). As such, average sizes of steelhead smolts in 2013 were larger than those trapped in the mainstem in 2003, and similar in size to those captured exiting the off-channel habitat in 2003. Condition factors in 2003 were similar at 0.93 (creek) and 0.92 (pond).

Outmigration timing

Coho smolt migration timing along the central California coast has been studied in some detail. The results of a 9-year coho salmon and steelhead study on Waddell Creek show that the great majority of coho smolts enter the ocean during the months of April and May, with over 95% of the migration occurring during the 9-week period of April 8 through June 9 (Shapovalov and Taft, 1954). In 2013, 99% of all coho salmon smolts were captured in the outmigrant trap during that period, and the peak of the outmigration occurred during a 3-week period extending from May 3 through May 23 (Figure 4-3) during which 57% of the migration occurred. The peak of the steelhead smolt downstream migration occurred approximately one month earlier during the 3-week period of April 5 through April 25 (Figure 4-3), during which 63% of the migration occurred.

The timing of the peak smolt outmigration in San Vicente Creek was very similar during 2013 and 2003 for coho salmon (Figure 4-4). For steelhead, the migration timing as depicted in Figure 4-5 suggests that the 2013 migration peaked approximately one week earlier than in 2003, but as described in ESA (2003), the trap was non-operational for a total of three days during the week of April 12 through April 18, 2003. This weekly period had the highest number of steelhead smolt captures in 2013, and may have also had the highest number of outmigrants in 2003 if the trap could have been operated during the entire period.

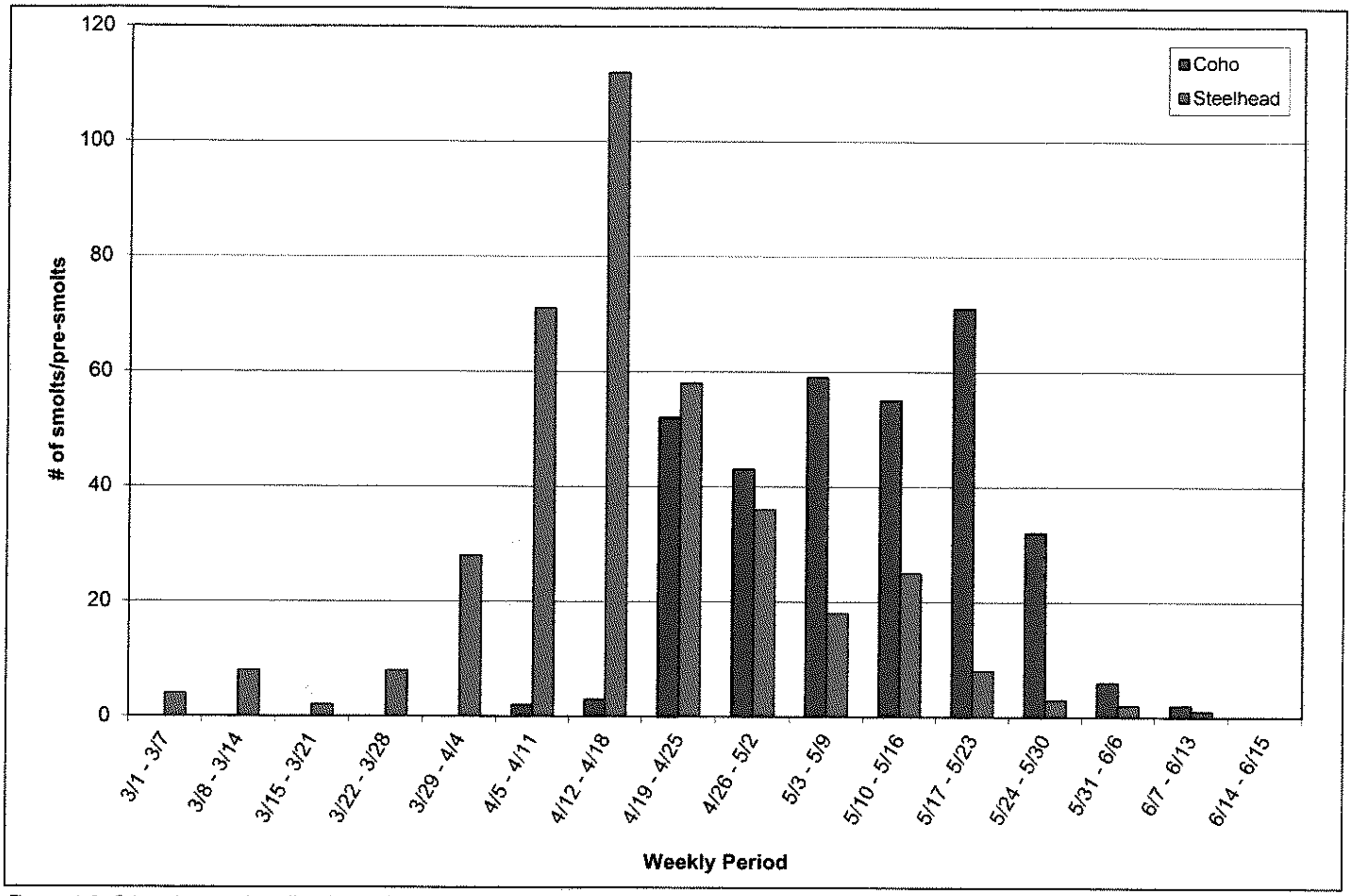
Juvenile Distribution

Of the 131 pool habitat units surveyed by SWFSC staff, 66 (50%) contained one or more juvenile coho salmon (Figure 4-6). Notably, only 5 individuals were observed above stream mile 1.9 where a large debris jam restricted passage by adult salmon the previous winter. No redds or live adults were observed upstream of this point during the 2011-2012 spawner surveys (Jankovitz, 2012). Consequently, coho salmon were absent from nearly 1.5 miles (45 suitable pool habitat units; Figure 4-7) of potential rearing habitat in the mainstem during the summer of 2012.

Many factors determine juvenile salmonid rearing habitat site selection, but the 2012 distribution data suggest that coho salmon rearing in San Vicente Creek is concentrated within reaches containing abundant and large pools. Furthermore, juvenile coho salmon in San Vicente Creek appear to remain relatively close to spawning sites. Juvenile coho salmon have been shown to migrate considerable distances from their natal reaches, but this tendency is typically thought to be a response to rising summer water temperatures forcing juveniles to seek out cooler rearing habitat elsewhere in the watershed. Relatively cool and stable summer water temperatures in San Vicente Creek likely reduce or eliminate the need for significant juvenile redistribution. It should be noted, however, that the lowermost reaches of the stream also show a concentration of coho salmon rearing, even though no redds were observed in this area during spawner surveys. A certain amount of downstream redistribution of juveniles occurs in most drainages.

Conclusions

As described above, the fisheries portion of this Existing Conditions assessment was initially envisioned to provide an evaluation of the current status of salmonids in general, and coho salmon in particular, within the watershed. The overall goal was to determine whether coho salmon were still utilizing San Vicente Creek. However, the focus of the assessment shifted after NOAA's SWFSC, in collaboration with MBSTP, embarked on a concerted coho salmon broodstock reintroduction and research effort. As such, the coho salmon population within the watershed is currently being artificially supplemented. Available data from a 2011-2012 spawner surveys, a July 2012 juvenile distribution survey, and a spring 2013 smolt outmigration study indicate that limited spawning is occurring, and at least a portion of the offspring and/or broodstock juveniles are successfully rearing and subsequently migrating to the ocean. The proportion of the wild versus broodstock coho salmon in San Vicente Creek is currently unknown, but this information will become available once the genetic samples that have been collected over the past two years are analyzed.



Figures 4-3. Coho salmon and steelhead smolt/presmolt migration timing, San Vicente Creek, March 1–June 15, 2013.

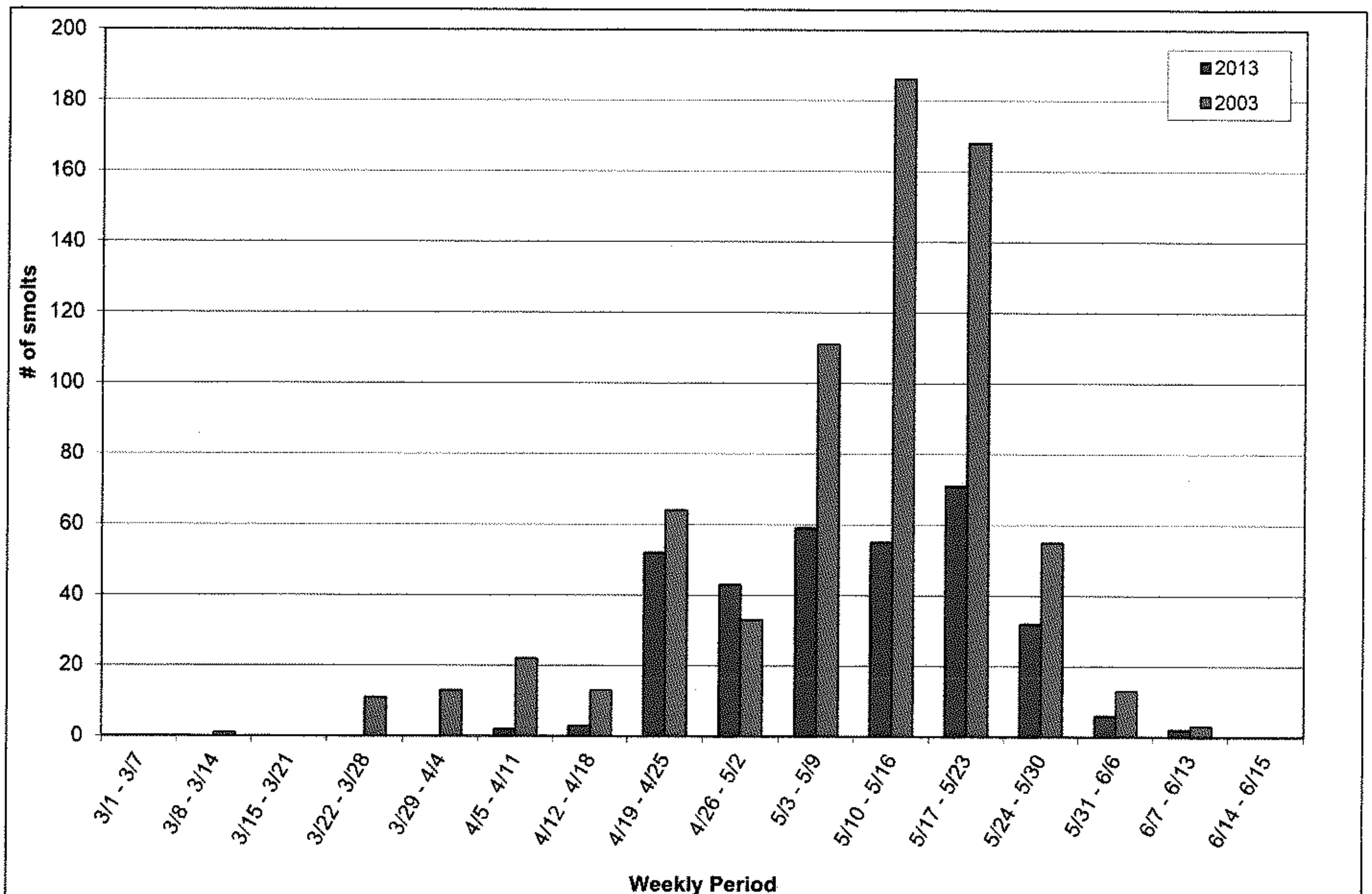


Figure 4-4. Coho salmon smolt migration timing, San Vicente Creek, March 1 –June 15, 2013 and 2003.