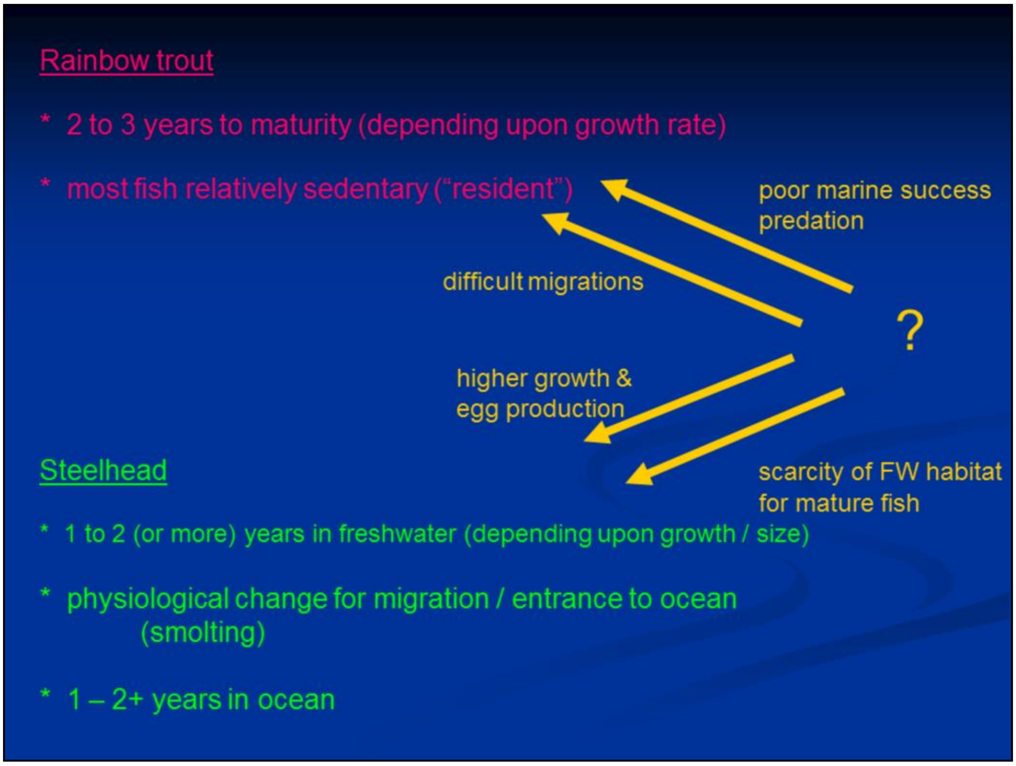
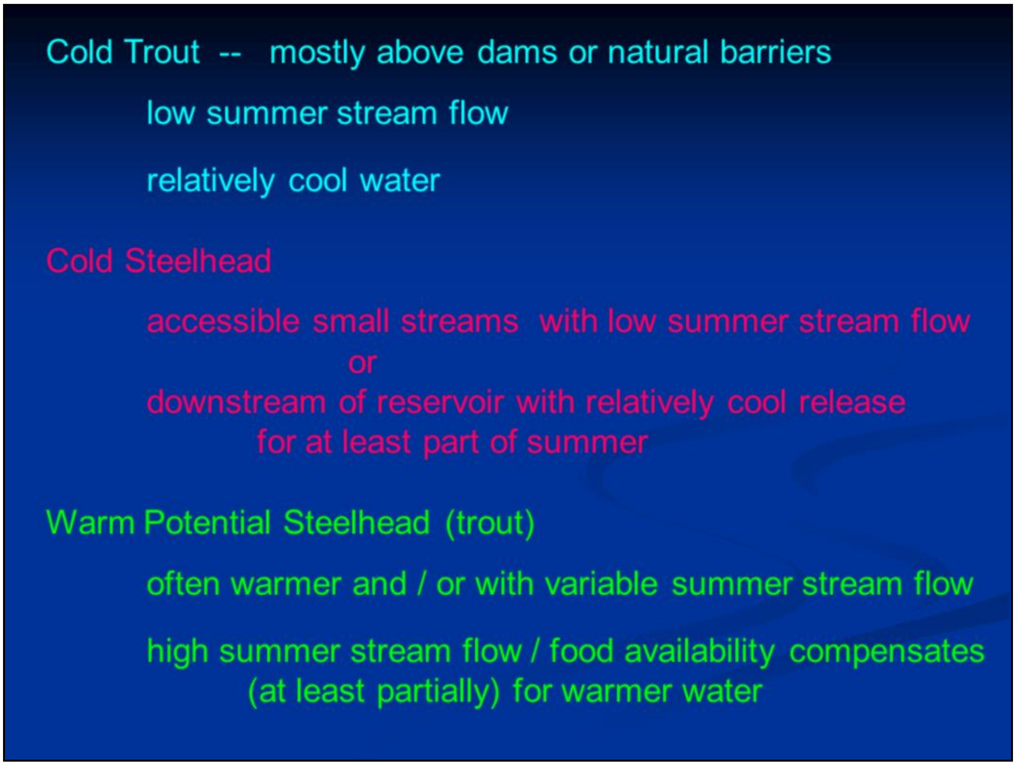
The fish on this introduction slide is a male steelhead that we caught in late October 2011 in Upper Penitencia Creek in Alum Rock Park. Based upon the growth pattern on some scales that were removed, it spent one year in fresh water, one year in the ocean, and then came into the stream this spring and stayed, or got stuck, for the summer. The red stripe and red on the gill cover are typical of "rainbow trout" colors. Steelhead are silvery in the ocean or as juvenile fish preparing for a migration to the ocean. If they are in fresh water for an extended length of time they develop the rainbow coloration.



Rainbow trout and steelhead are the same species, but steelhead have the wandering trait. Fish that stay in freshwater (resident rainbow trout) mature at 2 to 3 years old, depending upon growth rate, and usually at a relatively small size compared to fish that go to the ocean.

Steelhead spend 1 or 2 (or more) years in freshwater, depending upon growth rate. They then undergo some shape, color and physiological changes (turning skinny and silvery, with black tips of the tail, and changing salt regulation adaptations in their gills) that will allow them to transition to, and survive in, the ocean. They usually spend 1 or 2 years in the ocean before maturing and returning to the stream they were raised in to reproduce.

The potentially much higher growth rate of steelhead in the ocean, compared to fish that remain in fresh water, allows them to produce many more eggs and out reproduce the resident fish. Steelhead life style is also favored if habitat for reproductive aged and sized fish is limited in the freshwater habitat. On the other hand, if the migration to and/or from the ocean is difficult or curtailed, the fresh water resident life style is favored. This can occur if upstream adult passage is blocked or inhibited by dams, falls or other barriers, or if the stream usually dries in downstream reaches prior to the migration of juveniles to the ocean. If the ocean conditions are unfavorable, due to periodic collapses of ocean upwelling conditions that disrupt the food chain or increased predation on ocean fish, then the resident lifestyle is also favored. For example, heavy ocean harvest of Atlantic salmon off New England and Canada selected for male salmon that remained in the stream (safe from nets, but producing relatively tiny male adults). Female salmon still migrated to the ocean, because their egg production was substantially enhanced by ocean growth.

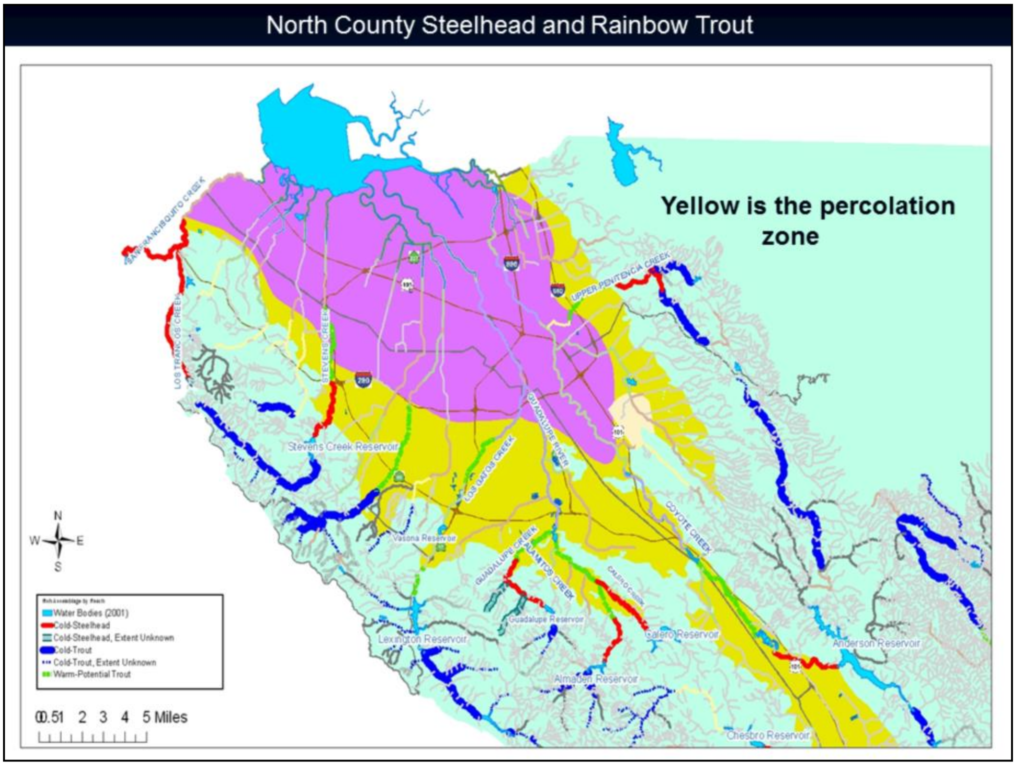


For Santa Clara County streams the potential fish communities were mapped by myself and by Jae Abel of the Santa Clara Valley Water District as part of the support information for the Santa Clara Valley Habitat Conservation Plan. (However, the fish were removed from present consideration in the Santa Clara Valley Habitat Plan, because resolving mitigation conflicts for fish would have delayed the terrestrial portion of the plan.)

For the steelhead or rainbow trout communities we mapped 3 community types. The Cold Trout community (mapped as blue on the following maps) is mostly upstream of reservoirs or other barriers to migration. These streams tend to have low summer stream flows, but are relatively cool.

The Cold Steelhead community (mapped as red on the following maps) is primarily downstream of reservoirs with relatively cool summer releases during at least much of the summer (Anderson, Guadalupe, Almaden and Stevens Creek reservoirs in the north county and Uvas and Chesbro reservoirs in the south county). This community also is found in Upper Penitencia Creek (in Alum Rock Park) and Tar, Bodfish and Little Arthur creeks in the south county, which are accessible but small, relatively cool streams with low summer stream flows.

The Warm Potential Steelhead/Trout community (mapped as green on the following maps) is usually below reservoirs, but farther downstream of the cold steelhead community. Water temperatures are warmer and/or availability of suitable summer stream flow is more unlikely in drier years. For portions of this community, high summer stream flow and good food availability can compensate for the warm water.



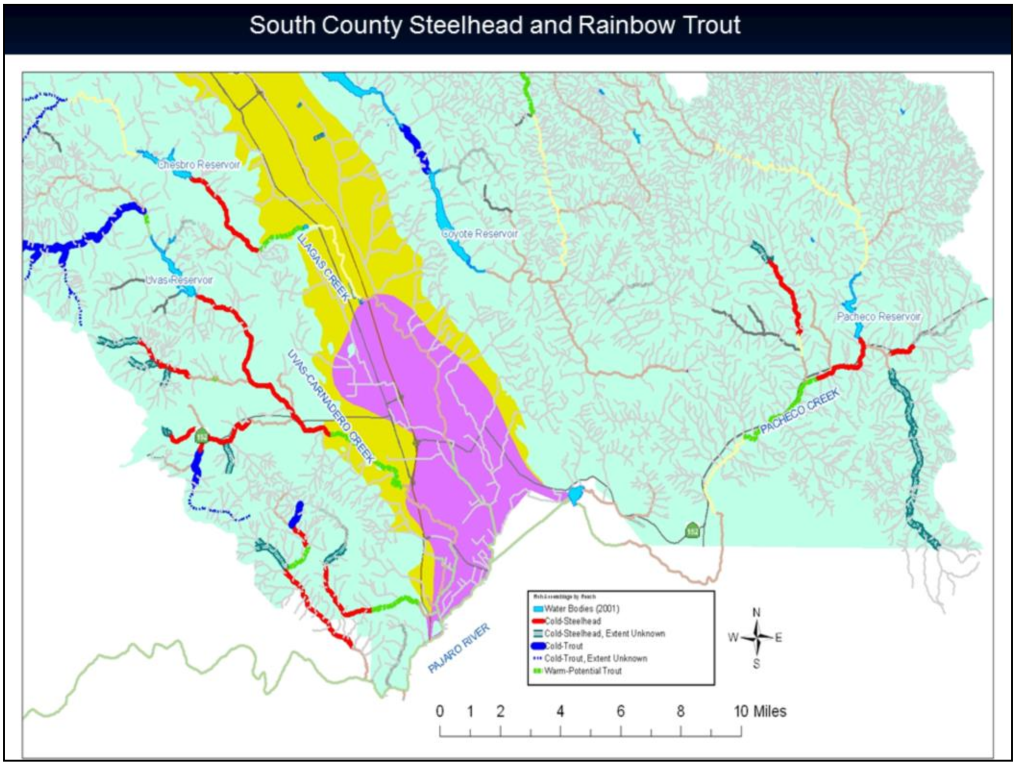
In this map of north county streams, the blue is the Cold Trout community, the red is the cool steelhead community, and the green is the potential steelhead/trout community.

Most of the cold trout community is upstream of reservoirs, such as Stevens Creek, Lexington, Guadalupe, Almaden, and Anderson reservoirs. It also is found on upper Saratoga Creek, because passage to and from San Francisco Bay is prevented by the channelized and percolating stream bed on the valley floor. Rainbow trout are also found above waterfalls in the Upper Penitncia Creek watershed in Alum Rock Park.

The reservoirs in the county are primarily used to capture winter storm runoff and percolate it in the stream bed, or in associated percolation ponds, in the yellow zone shown at the edge of the valley. This zone is in contact with the deep aquifer that provides domestic water for the valley. The pink zone, further downstream, is a clay zone that doesn’t allow recharge of the water supply aquifer (but may percolate water to an upper “perched” aquifer).

In Stevens, Guadalupe, Alamitos, Calero, and Coyote creeks, there are cold steelhead zones and also warmer potential steelhead zones downstream of the reservoirs. Lower Los Gatos Creek has a potential steelhead zone downstream of the percolation ponds and the Camden drop structure. On Coyote Creek the switch in zones is at the Ogier Ponds, which are a series of on-channel ponds that substantially increase stream temperature downstream. (The wide, shallow ponds collect heat; in addition, cool, heavy water enters and sinks in the ponds and warm surface water flows out). San Francisquito and Los Trancos creeks on the northern boundary are cool steelhead streams, but have very low summer flows. As you can see, there is a negligible yellow percolation zone for San Francisquito Creek, and there are no large water supply reservoirs or percolation operations in the San Francisquito watershed. Heavy pumping by private streamside wells severely reduces the extent and quality of steelhead rearing habitat in the watershed and makes outmigration of juveniles to the bay difficult in spring. In Upper Penitencia Creek a potential (warm) steelhead community exists downstream of Alum Rock Park, usually (except in severe drought) supported by spring through fall releases from percolation ponds using imported water from the South Bay Aqueduct.

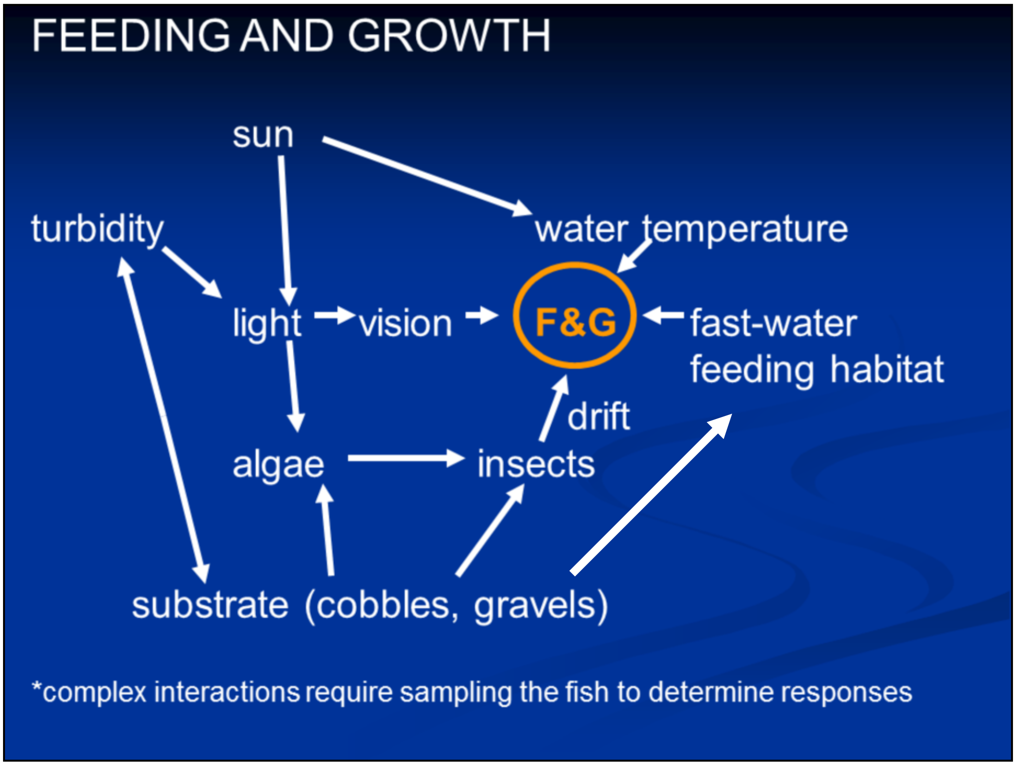
Late summer sampling has shown that Stevens, Guadalupe, Coyote, and Upper Penitencia creeks cave had steelhead runs until the 2012-2016 drought. Upper Penitencia, Stevens, and Guadalupe Creeks also have resident rainbow trout populations. However, blocked or reduced adult and smolt passage in the drought and apparently severely reduced or eliminated steelhead spawning and rearing by 2015. The extent and size of steelhead runs elsewhere in north county has not been determined by late summer sampling (San Francisquito, Los Gatos, and Alamios creeks).



In the south county the cold trout community exists upstream of Chesbro and Uvas reservoirs, between Coyote and Anderson reservoirs, and above barriers on Bodfish and Little Arthur creeks.

Percolation operations by the Santa Clara Valley Water District support cool steelhead and warm potential steelhead communities downstream of Chesbro and Uvas Reservoirs. However, very difficult up and downstream migration make the steelhead run in Llagas Creek (below Chesbro Reservoir) very small, sporadic, and precarious. Two tributaries to Uvas Creek downstream of the reservoir, Bodfish Creek and Little Arthur Creek, also potentially support steelhead spawning and rearing. In addition, a tiny tributary immediately downstream of Uvas Reservoir ("Dave's Creek) provides steelhead spawning, but dries early in spring, often trapping steelhead fry. Bodfish Creek is rather dry and unable to support many rearing steelhead in drier years. Little Arthur Creek is in a dry hilly watershed, but formerly supported steelhead. However, residential and vineyard development in the watershed have substantially reduced summer stream flow and steelhead habitat in the watershed. In addition, erosion from development and vineyards has severely increased sedimentation of the creek and of Uvas creek downstream of Little Arthur. In dry hilly watersheds vineyards appear to be a very efficient way of eliminating summer stream flow and replacing it with silty substrate; wine appears to be a minor byproduct of vineyards in such watersheds. Uvas, Llagas and Bodfish creeks have been usually been sampled annually since 2005 as part of an effort to modify the reservoir release patterns for Uvas Creek. As for north county streams, Uvas Creek (and other south county streams were severely impacted by the 2012-2016, and there was little or no steelhead production in 2014-2016.

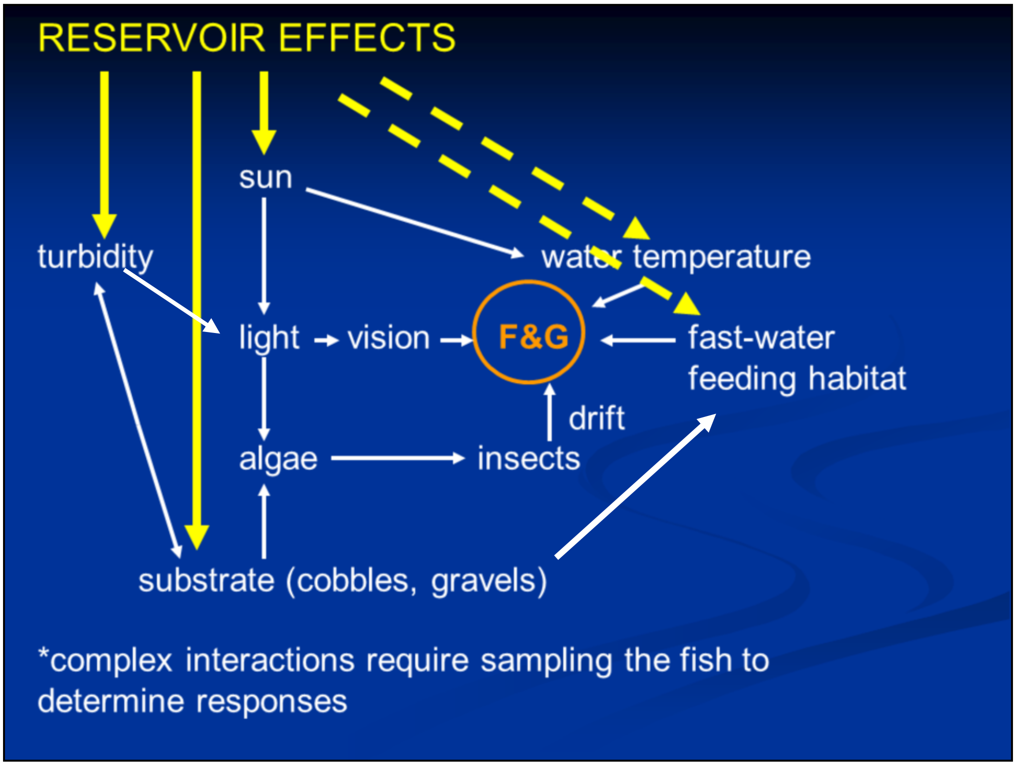
On Pacheco Creek summer releases from the small North Fork Pacheco Reservoir formerly supported cool steelhead and warm potential steelhead on Pacheco Creek. However, releases 2002-2012, bracketed by little or no release and a drying stream bed in early summer and in fall, eliminating steelhead and also killing many of the streamside sycamores. A grant-supported study of reoperation resulted in perennial flow to a portion of the stream bed in 2013, 2015, and 2016.



Shifting from the brief comments on status of steelhead in the county, I now discuss the complex ecology of steelhead. Unlike birds and mammals, where size of individuals varies only during brief growth periods, fish growth and size are major issues of their ecology. Fish growth occurs over many years, and size has major implications for habitat requirements, food habitats, and physiology. For example, adult steelhead size is a determinant of migration ability and egg production, size of smolts entering the ocean affects their ability to transition from fresh to salt water and to survive ocean predators, and size of rearing juvenile steelhead affects their food demands, habitat depth and escape cover requirements, and even tolerance of low dissolved oxygen or toxic pollutants.

Factors that affect feeding and growth (F &G) include water temperature, which is affected by air temperature and solar heating. However, the sun also provides the light necessary for visual feeding by the fish and for growth of algae to provide food for the aquatic insects that steelhead feed on. Shade, which might be desirable for keeping stream water temperatures cool can, therefore, also reduce the food and feeding by juvenile steelhead. Silty (muddy) substrate reduces the ability of the stream bed to support aquatic insects as fish food; it also increases turbidity (cloudiness) of the water, interfering with visual feeding. Silt settling from turbid water degrades the substrate for insect production. Finally, insects rinsed into the water column as “drift” provide for efficient feeding by juvenile steelhead if fast-water feeding habitats (riffles, heads of pools) provide a conveyer belt for them to feed in. In the percolating channels on the floor of Santa Clara Valley substrate conditions can even affect the extent of surface water and the availability of fast-water habitat; siltier channels (less desirable for insects and water clarity) percolate slower, maintaining and extending the stream flow. “Improved” substrate of clean gravels and cobbles (better for insects and turbidity levels) results in faster percolation of stream flow, causing flows to decline much sooner.

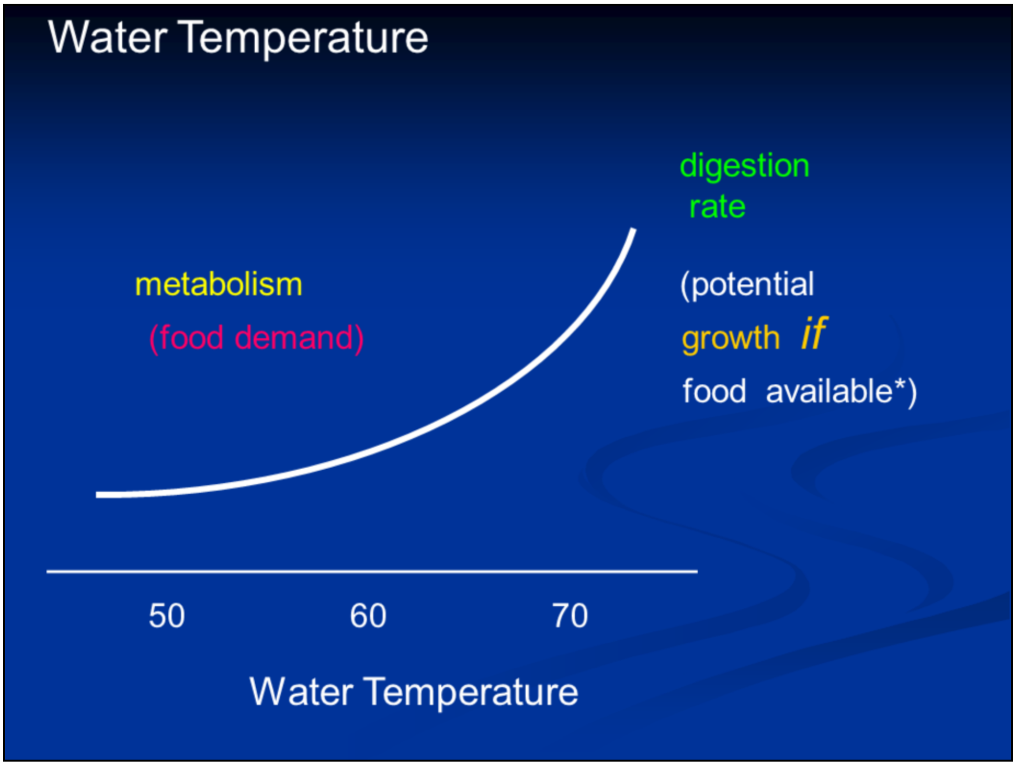
Because of the complex interactions of so many factors affecting juvenile steelhead growth, models or single factor management are often erroneous. Sampling the fish to determine density, condition, and growth rates is needed to determine what “works” in a particular complex combination of conditions.



Since much of the steelhead habitat in Santa Clara County is downstream of reservoirs, we should look at how reservoirs can affect those same factors that affect feeding and growth.

One effect of the flood reduction and drought prevention effects of capture and storage of runoff in reservoirs is to cause the streamside vegetation to dramatically increase, increasing shading of the channel. Although this may reduce the warming of the stream, by reducing light it can also reduce algal growth and insect production as fish food. The increased shading can also reduce feeding efficiency of fish, just as cloudier water can. The lack of flood scouring can also prevent the flushing of silt from the substrate, reducing the quality of the stream bed for aquatic insects (fish food!) and for spawning (reproduction) by steelhead. Finally, our reservoirs capture the muddy storm runoff during winter and early spring. Courser sediments settle quickly in the calm water at the head of the reservoir, but the fine silts and clays remain suspended into April. This affects the turbidity of spring reservoir releases and the ability of steelhead juveniles to feed during the crucial period prior to and during their migration to the ocean. Reservoir releases may also be turbid during the fall if the reservoir level is low and/or the water column is mixed. The accumulated fine sediment in the stream bed can also reduce the efficiency of water supply percolation operations (but increase the distance that reservoir releases may travel downstream before percolating).

The two dotted arrows on the right address how the amount and timing of water releases from the reservoirs affect the amount of stream flow (and fast-water feeding habitat and amount of flowing stream length in summer) and the temperature of those releases. Since the reservoirs of Santa Clara County usually add to our water supply by percolating the stored water in the downstream channels (rather than being piped directly to a water treatment plant), summer stream flow in many of our streams is higher (often very much higher) than would have occurred historically. However, the amount of that increase and the temperature effects vary with watershed. For a large reservoir like Anderson (90,000 acre-feet capacity) the amount of cool water in the lower portion of the reservoir (heating is at the top and cool water is heavier) shouldn't be a constraint on temperature of water releases. Abundant cool water could potentially be released from the reservoir. However, Anderson releases have been from a warmer (by late summer), higher release port to supply both the stream and a water treatment plant. Coyote Creek also receives imported pipeline water (San Felipe Pipeline/San Luis Reservoir), which is warm in late summer. For smaller reservoirs like Stevens Creek and Guadalupe (3,000-3,400 acre-feet capacity) large releases draw down the reservoir, potentially draining out the cool water and producing warmer releases of upper level water by late summer or fall. Optimizing the release by balancing the water temperature versus the amount of release (which affects fast-water feeding habitat and extent of the wetted stream bed) then becomes a challenge. How that balance is achieved, given the complex factors involved in fish survival and growth, requires an understanding based upon sampling the fish to determine how they respond to different release strategies in different streams and stream segments and in different types of rainfall years.



Water temperature has a variety of potential effects on steelhead survival, feeding and growth. If the temperature is not high enough to directly kill the fish, the major potential adverse effect is on metabolic rate, which affects food and oxygen demand. An increase of about 18 degrees (from 54 to 72 degrees) would double the food demand. If food is scarce the fish might grow slowly or even gradually starve.

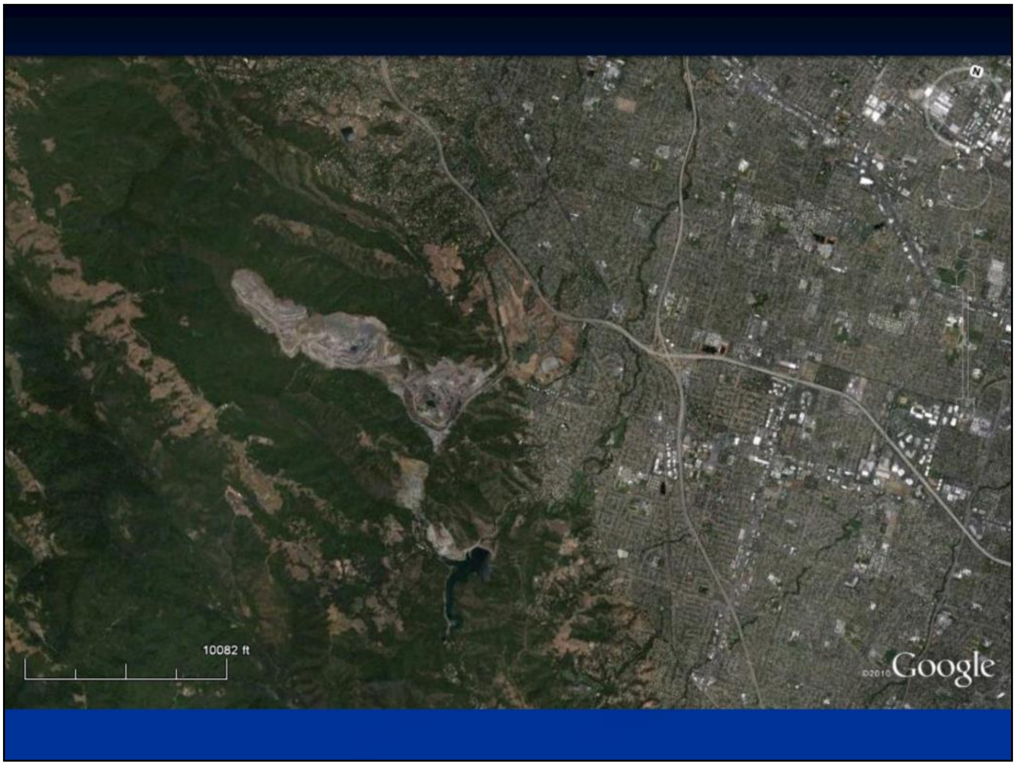
However, the higher temperature also increases the digestive rate in a similar fashion. This would allow the fish to more rapidly digest food and grow ***if food was readily available.*** Since food availability and fish growth are dependent upon the complex interaction of algae and insect production, water clarity, and fast-water feeding habitats, it may be hard to predict the ideal release strategy. Increasing stream flow might provide more fast-water feeding habitat, but could result in higher late summer water temperatures and poorer growth or survival if food is insufficient. On the other hand, smaller releases of cool water might reduce the amount of wetted stream and reduce or eliminate fast-water feeding habitat, producing poor fish growth or total numbers.

It is usually necessary to actually sample the fish under a variety of conditions to determine what strategy works best for fish. The correct strategy may also vary with amount of water available in different years and also upon water release needs in winter (for steelhead migration and spawning) and spring (juvenile migration to the ocean).

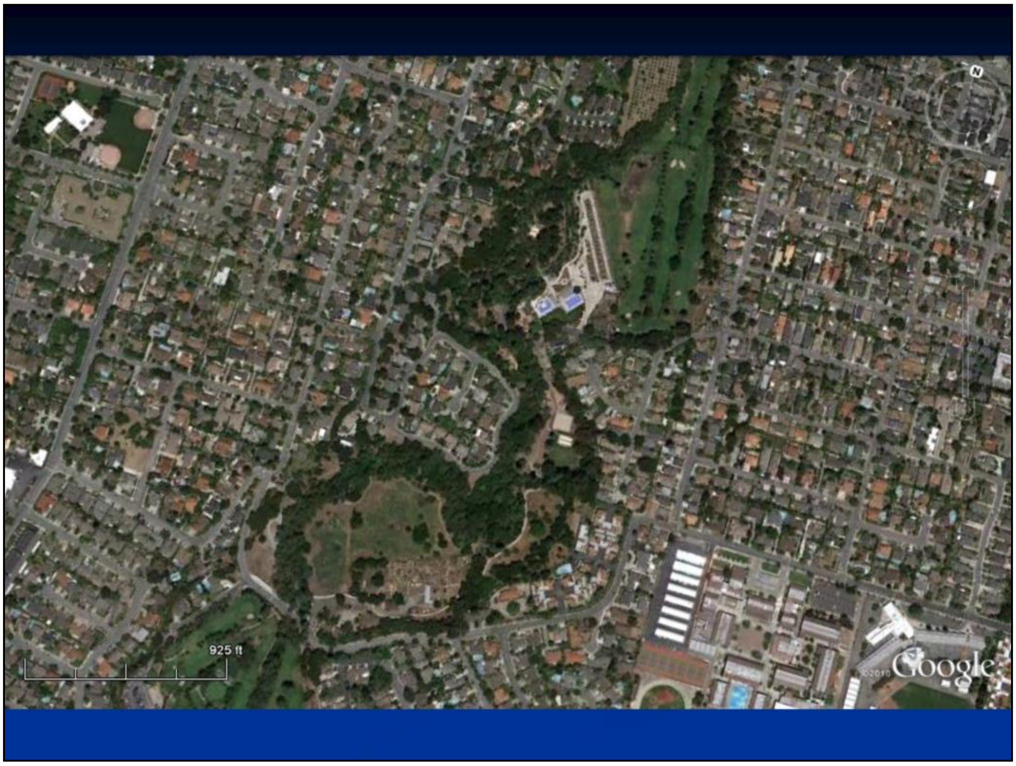
An example of how fish sampling illuminates steelhead ecology is the late summer fish sampling that the Santa Clara Valley Water District and the California Department of Fish and Game conducted on Stevens Creek in 2010. A backpack electrofisher was used to temporarily stun juvenile steelhead (and resident rainbow trout) so that they could be netted, placed in a floating live car, measured for length and aged by their scales. (In this picture 3 water district employees are on the left and the State Department of Fish and Wildlife regional biologist is on the right).

Sampling was conducted in very late summer, after fish had completed most of their yearly growth and when numbers had nearly stabilized after summer declines. Representative habitats were sampled at numerous upstream to downstream sites to represent changes in stream flow, water temperature, turbidity, and local conditions of substrate and tree canopy density.

Stevens Creek provides a good example of how steelhead are affected by habitat conditions, with 2010 indicating the potential in a very wet year, when adults had easy access throughout the stream for spawning and when releases from the reservoir maintained summer-fall stream flow downstream past Remington Ave.



Here is a Google Earth view of much of the Stevens Creek watershed. Most of the natural upstream watershed is above Stevens Creek Reservoir (lower middle of the picture). The upper watershed supports a resident rainbow trout population. However, most of the potential steelhead habitat is surrounded by dense urban development. This also means that the steelhead rearing habitat is subject to other effects not mentioned previously, such as illegal discharges to storm drains and to the first flush from fall rains of oils, copper, and other toxins from the streets. The streets, parking lots, roofs, and other impervious surfaces in the urbanized landscape also produce much greater runoff during storms, rinsing out steelhead nests and altering the channel, but providing easier upstream access by adult steelhead. The increased runoff also produces the need for channel and bank alterations for flood control.



This middle view of Stevens Creek (flowing north, top of picture) shows the urban development, the Deep Cliff Golf Course (at the bottom), McClellan Ranch, and Blackberry Farm. The stream generally flows in a heavily shaded channel (the twisting green line) that has resulted from a combination of channel down-cutting and the lack of floods and droughts to clear streamside trees and create a mosaic of streamside vegetation heights.

This view zeros in on Blackberry Farm and shows the (2008) constructed channel paralleling the parking lot on the right. This new channel was deeply excavated, back-filled with clean cobbles and gravels, and includes boulders and tree roots anchored to the bank. It was also one of the few places on the stream where you can actually see the flowing stream from above, because the trees were new and still small. However, by 2014-2016 the canopy had nearly closed over, reducing light to support algae (and aquatic insects as fish food), and the shade also reduced visibility by steelhead feeding on drifting insects. In addition, turbid reservoir releases during the drought resulted in silting up the clean cobbles and gravels in the relocated channel, so conditions were similar to the silty, shaded habitats up and downstream.

Rainbow trout / steelhead lengths (mm) versus location on Stevens Creek in 2010
(numbers refer to ages of fish as determined by scales)

Fork Length	County Park	Deep Cliff	Blackberry 1	Blackberry 2 X 2
40	*****			
50	000**********	*******		
60	00000*****	***********	**	
70	00000*******	0001*************	************	**
80	00000000	0000000001********	000************	****
90	000000000000*	01***	000000*****+13	************
100	00		000***********	**********************
110	0001	11111111111***	****	00000000000000000
120	1111111111	1111111	1*	000000000001
130	11111	11111**	*	001*
140	111111	22		111111
150	112**	1	11*	112
160	1122			112
170				1112
180	2*	22	2	12
190	*	2	*	12
>200			*	22
Density: # / 100 ft	32	35	39	51

These data (and the next two slides) summarize some of the results from the sampling in 2010. Fork lengths in millimeters increase from top to bottom; 50 mm is about 2 inches, 100 mm is about 4 inches, and 150 mm is about 6 inches. The * or numbers indicate the number of fish captured of that size for each site. The numbers are the age of fish as determined from their scales.

The smaller fish indicated in red are fish that are probably too small to migrate to the ocean and survive, even if they were able to grow the following spring before migrating (red=stop!). The fish larger than 4 inches (100 mm), in green (=go!) are probably large enough to go to the ocean the following spring after completing some additional spring growth.

At the most upstream sites, at the County Park below the dam and at Deep Cliff, most of the young-of-year fish were too small to go to the ocean and must remain and grow for an additional year in the stream. Yearling fish were relatively abundant, indicating good over winter survival; these fish are large enough to go to the ocean the following year, after adding some spring growth. The two sites are well-shaded, have cooler but more turbid water (closer to the reservoir release), and have siltier substrate than farther downstream.

Fish were somewhat larger at the shaded upstream site at Blackberry Farm (1), so a larger proportion of young of year (YOY) fish might migrate the following spring. The relative scarcity of older fish further indicates that many of the YOY grew enough to emigrate as yearlings. Stream flow was similar to upstream, but somewhat clearer, and the substrate was a bit cleaner.

Most dramatic was the much larger size of young fish at the new, constructed sunny channel at Blackberry Farm (2). The majority of YOY fish were large enough to migrate as yearlings. The overall density was also substantially higher than at the 3 sites upstream. In addition, because of the faster growth, the density of fish big enough to migrate the following spring was more than 3 times that of any other site. Scales indicated that many of the yearling fish grew much more poorly in their first year, and probably moved down from upstream sites. Little percolation had apparently occurred upstream (silt-sealed channel). Stream flow at the site was similar to upstream, but somewhat clearer and warmer. The recently added gravels and cobbles were much cleaner.

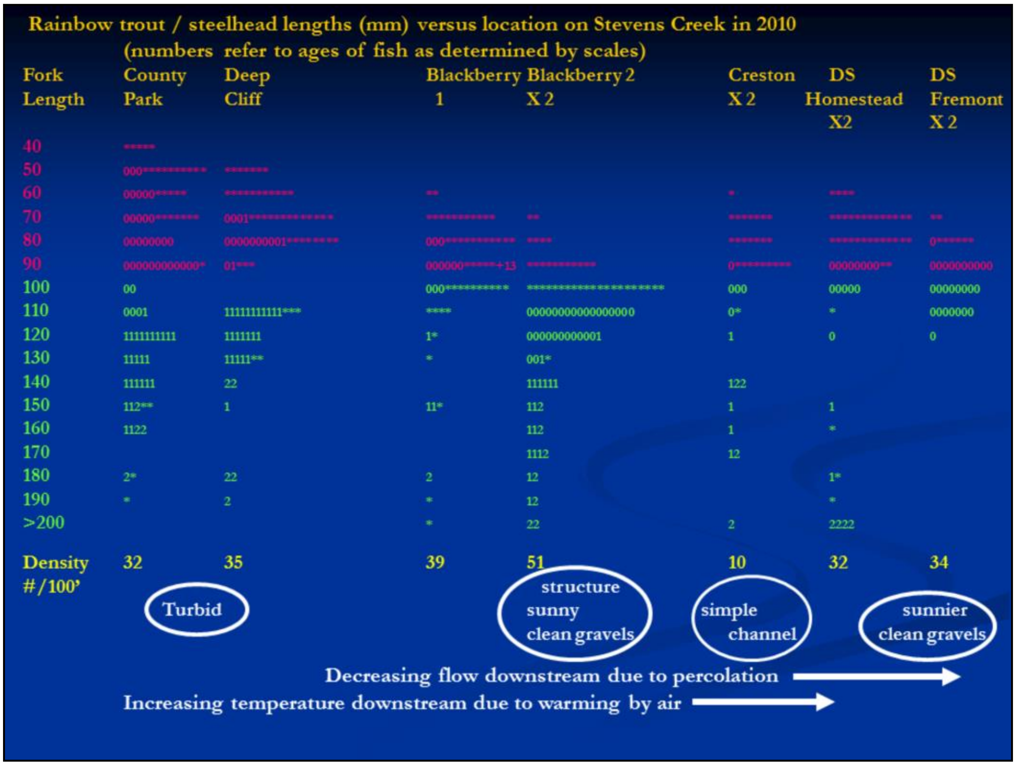
Steelhead adults and smolts have been observed in the stream. However, at all of the sites shown here the presence of numerous 2 year old fish that were large enough to migrate in spring, but remained in the stream, and the presence of spawning marks on the scales of some fish, apparently indicate that a portion of the fish are resident rainbow trout, rather than steelhead.

Rainbow trout / steelhead lengths (mm) versus location on Stevens Creek in 2010
(numbers refer to ages of fish as determined by scales)

Fork Length	Blackberry 2 X 2	Creston X 2	DS Homestead X2	DS Fremont X 2
40				
50				
60		*	****	
70	**	*******	*************	**
80	****	*******	*************	0******
90	***********	0*********	00000000**	0000000000
100	*********************	000	00000	00000000
110	00000000000000000	0*	*	0000000
120	000000000001	1	0	0
130	001*			
140	111111	122		
150	112	1	1	
160	112	1	*	
170	1112	12		
180	12		1*	
190	12		*	
>200	22	2	2222	
Density: # / 100 ft	51	10	30	32

Blackberry 2 is shown again at the left for comparison with sites progressively farther downstream. The downstream sites had lower stream flow and warmer temperatures than upstream sites (County Park and Deep Cliff), but the sizes of young fish were larger, especially downstream of Fremont Avenue, where the channel was sunnier and the stream bed had less sediment. The cleaner substrate downstream of Fremont may result from greater distance from the reservoir, channel agitation/scouring downstream of a drop structure, and/or periodic drying in droughts. Older fish were relatively scarce, reflecting lower abundance or absence at the sites in 2009, which was a dry year with much less stream flow.

The most dramatic difference among the sites was the very low density of fish upstream of Highway 280 (Creston), with overall density less than 1/3 of other sites. The channel there is straight, rather flat, and substrate is sandier. Channel complexity is low, and structure such as boulders or downed trees is nearly absent.



Rainbow trout / steelhead lengths (mm) versus location on Stevens Creek in 2010
(numbers refer to ages of fish as determined by scales)

Fork Length	County Park	Deep Cliff	Blackberry 1	Blackberry 2 X 2	Creston X 2	DS Homestead X2	DS Fremont X 2
40	*****						
50	000***********	********					
60	00000******	************	**		*	****	
70	00000********	0001**************	************	**	********	**************	**
80	00000000	0000000001*********	000************	****	********	**************	0*******
90	000000000000*	01***	000000******+13	************	0**********	00000000**	0000000000
100	00		000***********	**********************	000	00000	00000000
110	0001	11111111111***	****	00000000000000000	0*	*	0000000
120	1111111111	1111111	1*	000000000001	1	0	0
130	11111	11111**	*	001*			
140	111111	22		111111	122		
150	112**	1	11*	112	1	1	
160	1122			112	1	*	
170				1112	12		
180	2*	22	2	12		1*	
190	*	2	*	12		*	
>200			*	22	2	2222	
Density #/100’	32	35	39	51	10	32	34

This is a summary combination of the previous two slides. Although stream flow declines downstream of Blackberry Farm (due to stream bed percolation) and water temperature progressively increases downstream of the reservoir, local habitat features, including substrate quality, amount of sunlight, water turbidity, and stream structural complexity appear to have been the dominant factors in fish abundance and size.

Drought year (2013 – 2016) Stevens Creek Resampling

Site	Steelhead/trout Density (# / 100 ft) 2010	2013	2014	2015	2016
County Park	32	9	0	4	
McClellan	16	5	1	1	2
Blackberry 2	51	8	1	1	1
Homestead	30	23	dry	1	1
DS Fremont	32	dry	dry	dry	--
*Supported by reservoir releases					
Moffett*	0	8	0	0	0
<Highway 101*	2	24	0	0	0
*Supported by emerging ground water					

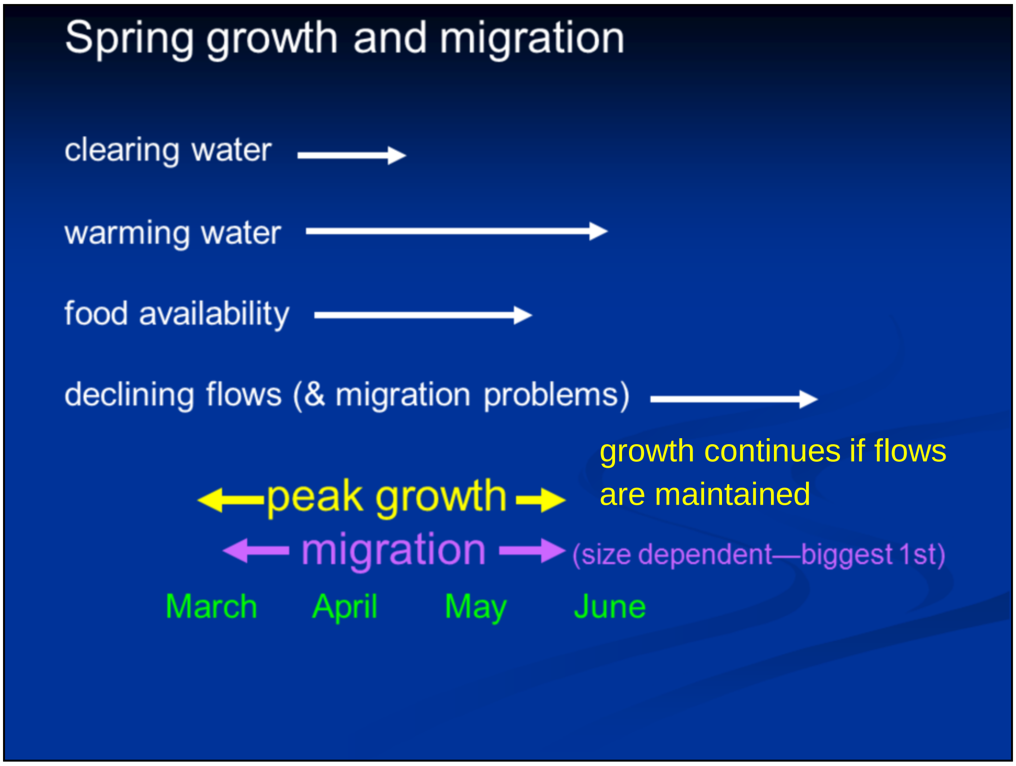
Adult access in 2013 apparently limited spawning primarily to the Homestead Rd area and downstream of Evelyn Avenue (where ground water supported summer rearing). Poor smolt migration conditions in 2013-2015 and poor adult access in 2013-2015 apparently resulted in the loss of steelhead and a small resident rainbow trout population.

At Stevens Creek in 2013, releases from the reservoir were insufficient to allow most adult steelhead to access spawning and rearing habitat supported by summer releases. Steelhead apparently spawned near Homestead Rd., but insufficient flows and a logjam apparently prevented most or all access farther upstream. Low stream flows and a fish ladder and bypass channel obstruction near Evelyn Avenue forced adults to spawn in lower Stevens Creek. Steelhead successfully reared in the lower reach in 2013, which is supported by emerging groundwater downstream of a percolating channel reach that is dry in summer. The reach is apparently not used for spawning, when access upstream is suitable.

Smolt downstream access in 2013-2015 was also blocked by the drying middle reach and by the Evelyn channel obstructions. Smolt outmigration was probably limited to fish that reared downstream in 2013. Adult upstream access was restricted or blocked in 2014 and 2015 by low flows and the problem at Evelyn. The SCVWD remedied the Evelyn problem in fall 2015.

The fish present in 2014-2016 were apparently all (or predominantly) resident rainbow trout, and the steelhead run was extirpated or near extirpation.

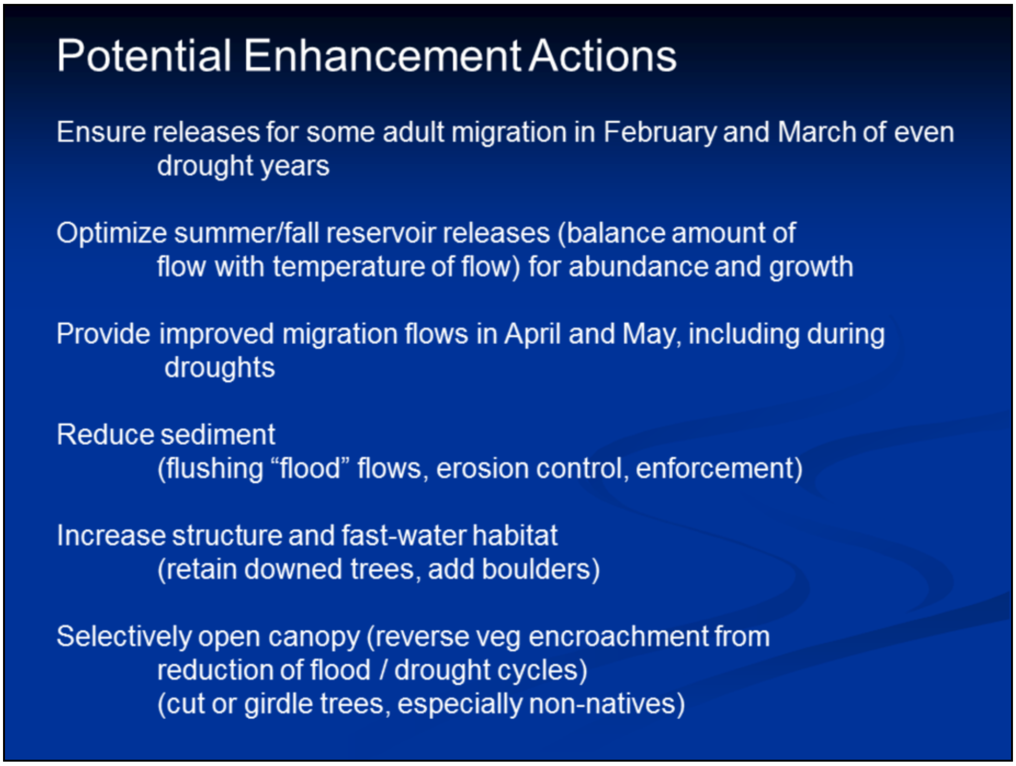
Similar, drought-related passage problems for adults and smolts during the drought apparently produced similar results in Coyote Creek, Upper Penitencia Creek, and Guadalupe Creek in north county and in Uvas Creek in south county.



In addition to rearing, a dominant control on steelhead success in Santa Clara County watersheds is the opportunity for spring growth and for outmigration to the ocean.

Declining stream flow in spring can block fish attempting to migrate in late March through May. However, this is when the peak migration of juvenile fish tends to occur, rather than winter or early spring when stream flows are higher. The reason is that clearing and warming water and increased food availability make that same period the best growth period in most streams. Fish that are small can substantially increase their size and improve their transition to salt water and predator avoidance by growing, rather than migrating early. Bigger fish require less growth and have the luxury of migrating early, but smaller fish must wait and risk being trapped (or killed) during their outmigration.

In the Guadalupe River system and in lower Coyote Creek migration flows are usually suitable, except in droughts, in April and May, . However, for San Francisquito, Stevens and Upper Penitencia creeks in north county and Uvas, Llagas and Pacheco creeks in south county, stream flow has often been too low in April and May for juvenile steelhead outmigration. On Uvas Creek a modification of reservoir releases has provided outmigration flows since 2005, somewhat reducing water available for summer rearing and for ground water percolation.



A *partial* list of potential enhancement actions includes:

Optimizing the releases from reservoirs in summer and fall to provide the highest growth and abundance of steelhead, based upon the conditions in individual streams. Strategies based upon maximizing only one factor, such as amount of wetted stream or water temperature should be tempered by the results of sampling of the fish under a variety of conditions.

Priority use of the stored reservoir water should improve flows for steelhead outmigration in April and early May and ensure some adult access in late winter to spawning and rearing areas, *even during droughts*. If passage is blocked in consecutive years, steelhead populations can be lost, regardless of rearing conditions.

Stream substrate conditions should be improved by preventing inputs (erosion control and enforcement) and by periodic flushing flows (floods!) to stir the gravels and cobbles. More complex channels also tend to move and sort cobbles and gravels.

Structures such as downed trees and boulders can be used to improve escape cover, high flow refuges, but also especially to provide fast-water feeding habitat.

Selectively opening the canopy over riffles, heads of pools and other food production and feeding habitats can improve fish growth. This will restore the more varied mosaic of vegetation heights that existed prior to the reduction of natural floods and droughts. This habitat mosaic will not only benefit steelhead, but also provide necessary basking habitat for western pond turtles and frogs. A vegetation mosaic is also preferred by some bird and mammal species.

Acknowledgments

Stevens Creek fish abundance and size data are from the Santa Clara Valley Water District 2010 study

Fish association maps are modifications of maps originally developed by Jae Abel of SCVWD and Jerry Smith for the Santa Clara Valley HCP

Sampling in 2013-2016 in Stevens, Upper Penitencia, and Coyote creeks and Guadalupe Creek in 2015-2016 was conducted by Jerry Smith, Michelle Leicester (DFW), Neil Keung, and Matt Fransz