DISTRIBUTION AND ABUNDANCE OF JUVENILE COHO AND STEELHEAD IN GAZOS, WADDELL AND SCOTT CREEKS IN 1996

Jerry J. Smith
Department of Biological Sciences
San Jose State University
San Jose, CA 95192
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ABSTRACT: In 1996 previously sampled representative sites on Waddell Creek, Gazos Creek and in the Scott Creek watershed were sampled by electroshocker to assess distribution and abundance of steelhead and 1996 year class coho. Adult coho were abundant on Scott and Waddell creeks in 1995-96, but some redd destruction apparently occurred with floods on Waddell Creek. Waddell Creek coho abundance in 1996 was the highest yet recorded, with wild-spawned coho relatively common on the West and lower East forks and a mixture of wild-spawned and planted fry common at all sites on the main stem. Coho juveniles were abundant at most Scott Creek sites, with the high abundance at the 2 downstream sites likely due to plants of fry. Gazos Creek coho abundance was approximately tripled compared to 1993, with planted fry an important part of the increase. Two out of three coho year classes are strong on Scott Creek, while 1 out of 3 are now relatively strong on Waddell and Gazos creeks. Use of large, hatchery-reared smolts may produce precocial females to reinforce weak year classes.

Steelhead numbers have been relatively stable in Waddell Creek over the past 5 years, but have fluctuated more dramatically in Gazos and Scott creeks. In Scott Creek YOY steelhead numbers are apparently suppressed by either low summer streamflow or competition with coho for pools. The lagoon at Waddell Creek is a very important component of steelhead production in that watershed.

Mortality of electroshocked fish reached 1.7% for coho on Waddell Creek, but since only a small amount of habitat was sampled the population effects were probably < 0.2%. Mortality for steelhead was less, and mortality also appeared to decline with cooler water or shallower, simpler habitats. Annual electroshock sampling should continue in order to provide an index of steelhead and coho status.

INTRODUCTION

Since all wild female southern coho (*Oncorhynchus kisutch*) spend one year in the stream and two years in the ocean prior to spawning (Shapovalov and Taft 1954), at least three consecutive years of study are necessary to determine the status of the three numerically independent year classes. Previous surveys of Scott and Waddell creeks (Santa Cruz County) in 1988 and 1992-1995, Gazos Creek (San Mateo County) in 1992, 1993 and 1995, and Redwood Creek (Marin County) in 1998 and 1992-1996 have shown wide year-to-year variation in coho abundance within streams (Smith 1992, 1994a, 1994b, 1994c, 1995a, 1995b, 1996; Smith and Davis 1993). These wide coho abundance differences occur because the restricted spawning period, single spawning attempt, and rigid ages of smolting and spawning (Shapovalov and Taft 1954) make them susceptible to drought, floods or other "disasters" within small watersheds (Smith 1994c). For example, Redwood Creek in Marin County had very strong coho year classes in 1992, 1993, 1995 and 1996, but the 1988 and 1994 year classes were less than 5 percent as large (Smith 1996), apparently reflecting impacts to that three year brood cycle prior to 1988. Steelhead (O. mykiss), however, have extended spawning periods, can spawn more than once, and are variable in ages of smolting and maturation (Shapovalov and Taft 1954). Therefore, steelhead juvenile abundance is more likely to indicate yearly habitat conditions, and populations are less affected by, and will recover quickly from, bad years.

Previous electroshock sampling on Scott Creek found strong juvenile coho year classes in 1988 and 1993 (January 1994 sampling), but very weak year classes in 1992 and 1994 (Smith 1992, 1994a, 1994c). In 1995 coho abundance rebounded from the 1992 low, apparently due to spawning by precocial, hatchery-reared females from the strong 1993 year class (Smith 1995b). The 1996 year class was expected to be strong, due to abundant adult returns from the strong wild and hatchery-reared 1993 year class. However, winter and spring 1996 storms could have destroyed redds or flushed fry from steeper upstream habitats, as occurred in 1995 (Smith 1995b). Unmarked hatchery-reared fry were released into the lower 2 miles of Scott Creek by the California Department of Fish and Game (CDFG) in April and May (Patricia Anderson, CDFG, letters of 17 April and 23 May). Fry plants of approximately 2350 fish were an effort to bolster juvenile coho abundance in a portion of the watershed which has previously reared relatively few coho (Smith 1992, 1994a, 1995b), possibly due to negligible spawning habitat in lower Scott Creek.

Previous sampling on Waddell Creek found weak year classes in 1988 and 1992, a stronger year class in 1993, but no apparent juvenile production in 1994 (Smith 1992, 1994c; Smith and Davis 1993). The 1994-1995 adult run was reinforced by precocial hatchery-origin fish, but the 1995 year class was weak, possibly due to heavy March 1995 flooding (Smith 1995b). The 1995-96 adult run was expected to be relatively strong, due to the stronger 1993 wild production and to a plant of hatchery-origin smolts from the Scott Creek watershed in the spring of 1994. However, winter and spring storms could have severely affected juvenile coho abundance, since Waddell Creek appears more flood-prone than Scott Creek (Smith 1994c). Approximately 2350 unmarked hatchery-origin coho fry were planted downstream of the East and West Fork confluence in April and May to increase 1996 juvenile abundance (Patricia Anderson, CDFG, letters of 17 April and 23 May).

Gazos Creek was sampled in fall 1992 and 1995 and January 1994

(1993 year class). No coho were found in sampling at 2 downstream sites in 1992 (Smith 1992). Coho were collected at two upstream sites added in January 1994, and were relatively common at the uppermost site (Smith 1994a). In 1995 only 1 coho was collected from among the 4 sites (Smith 1995b). Approximately 7000 unmarked hatchery-origin coho fry were planted in Gazos Creek in April and May 1996 (Patricia Anderson, CDFG, letters of 14 Mar, 17 April and 23 May), primarily 2 miles or more above Highway 1.

This report presents results of sampling for juvenile coho and steelhead on Gazos, Waddell and Scott creeks in August through November 1996 and limited surveying for adults on Waddell Creek in December 1995 and January 1996. Sampling results give an indication of 1996 wild production and of the effects of plants of hatchery smolts and fry.

METHODS

The lagoon at Waddell Creek was seined on 28 December 1995 as part of a study of steelhead growth and abundance in the lagoon. Fourteen adult coho were incidentally caught during the seining operation. The adults were measured, sexed and identified as wild or hatchery-origin fish, based upon fin clips (all of which were at least partially regenerated) and scales. Lack of rain during early January resulted in clear and low stream flows; many riffles were not passable and a portion of the adult coho were relatively visible while spawning or holding in the larger pools. Waddell Creek was walked on four days from 5-12 January to look for adults, redds and carcasses. Redds were flagged, and detailed descriptions of their configurations and locations recorded. Carcasses were measured, sexed, identified as wild or hatchery-origin, and scales were taken. Locations of observed adults were recorded, and fish were sexed and identified as wild or hatchery-origin, if possible. Fish missing most of their right pelvic fin could be confirmed as hatchery-origin, but many of the fish with apparently intact pelvic fins may have been of hatchery-origin, because of the high percentage of partial to nearly-complete regeneration of fins observed in seined adults and carcasses and in smolts in 1994.

In August and September 1996 all fourteen previously-sampled sites on Waddell Creek were sampled by electroshocking (Table 3). In October and November twelve Scott Creek watershed sites were sampled, including all 11 sites sampled in January 1994 (Table 4); a new site was added upstream of the hatchery on Big Creek to determine whether coho were present in the steeper, bedrock/boulder portion of the stream. In September all four previously sampled Gazos Creek sites were sampled (Table 5); limited sampling was also conducted in Old Woman Creek and on Gazos Creek immediately upstream of Old Woman Creek. At resampled sites on each stream the same habitats were resampled, if possible. Where the heavy runoff in 1996 had modified habitats, similar replacement stations were substituted. The length of stream and habitat types sampled in 1996 was similar to previous efforts in 1992-1995 for Scott and Waddell creeks (Table 6). On Gazos Creek additional run and riffle stations were added at each site, so that sampling was more representative of available habitats (Tables 5 and 6).

The primary goal of the sampling was to look for the presence and abundance of coho, so sampling was concentrated in pool and glide habitats. At each site usually three to five individual habitat "units" (a glide or pool, with its contiguous glide and run habitat) were sampled by 2 to 3 passes with a backpack electroshocker (Smith-Root Type 7, smooth pulse). Length, width, depth, cover (escape and overhead), and substrate conditions were determined, and percentage of habitat type assigned for each habitat unit. Rosgen channel type was determined, and relative abundance of pool, glide, run and riffle habitat types was also estimated for the site (Tables 3-5).

The partially closed lagoon at Waddell Creek was sampled by seine twice in July and once each in September, November and December to look for presence of coho and to determine sizes and abundance of juvenile steelhead.

Juvenile steelhead were measured (standard length, SL) in 5 mm increments, and young-of-year (YOY) steelhead were separated from older fish, based upon length-frequency at each site. Holdover hatchery steelhead were recognized by fin clips and/or worn, short dorsal fins. Juvenile coho were measured to the nearest mm (SL and fork length, FL). Mortality was kept to a minimum by reducing electroshocker voltage in shallow water and immediately placing captured fish in a floating live car. Mortality was recorded at the time of length measurements, and dead coho were frozen for genetic analysis.

A small portion (2 x 2 mm) of the caudal fin was taken from coho at 4 sites on Scott Creek (n=75) in late October and November and at 4 sites on Waddell Creek in November (n=81). Fin tissue samples were placed in buffered vials and transferred to a -80 degree freezer at San Jose State University. Samples will be transferred to CDFG to provide for genetic analysis.

RESULTS

Adult Coho and Redds on Waddell Creek

Eighty-two adult coho and 6 carcasses were observed while walking Waddell Creek on 5-12 January (Table 1). Because of dense cover in many of the habitats, this was substantially below the actual number of fish in the stream; rewalking a portion of the stream indicated that at least 1/4 of the fish were probably missed. Observed fish were spread rather evenly upstream of mile 1 on the main stem and on the West Fork (Table 1). However, only 1 fish was observed on 0.7 miles of the East Fork. Many of the fish were confined to large pools without access to suitable spawning habitat until storms later in January. However, 1/3 were courting, spawning or were spent females guarding redds.

Of coho for which sex could be identified, 36 were male and 38 were female (Table 2). Eight of the observed fish, including 3 females, were apparently two year old fish, based upon small size. All two year olds were probably hatchery-origin strays from Scott Creek, as 6 of the fish had apparent fin clips and no juvenile coho were collected from Waddell Creek in 1994 (Smith 1994c). Among the observed fish, hatchery-origin fish made up at least 16 of 44 (Table 2). Many of the apparently wild fish were probably also hatchery-origin fish with regenerated pelvic fins. A majority (12 of 21) of fish carefully examined after capture in the lagoon or recovered as carcasses were wild fish (Table 2).

Sixty-six early redds were present throughout the stream, but redds were scarce between mile 2.25 and the confluence, upstream of Buck Creek (Mile 4.7) on the West Fork, and upstream of mile 0.2 on the East Fork (Table 1). Suitable spawning sites were rare within those reaches. Redds were relatively common in the lower two miles of stream, even though most gravels were small and contained abundant sand. A large portion of downstream redds that were rechecked (at least 7 of 12) had apparently been destroyed by 26 January.

Juvenile Coho

Coho juvenile were collected at 13 of the 14 electroshock sites on Waddell Creek (Table 3); only the site upstream of Slippery Falls lacked coho. Overall density of coho at sampled sites was 12.5 fish per 100 feet, substantially higher than in previous years (Table 6). Low densities were found in Henry Creek, which suffered substantial flood damage, and at the uppermost sites with coho on both the East and West forks; the latter two sites are dominated by bedrock and/or boulders and are also subject to flood scour (Table 3). At the four remaining West Fork and East Fork sites, coho densities (10-23 per 100 feet; mean = 16) were not significantly different from the main stem sites (7-35 per 100 feet; mean = 16) (Table 3), even though fry equivalent to about 12-14 per 100 feet of stream were planted on the main stem in April and May. Coho made up about 1/3 of the YOY salmonids on the 3 West Fork sites, but were generally rare compared to steelhead on the main stem (Table 3).

Only 3 juvenile coho were captured by seining in Waddell Creek lagoon in early July, compared to 1340 steelhead. None were captured in the lagoon in late July, September or after mild storms in November. A single stream-reared (small) coho was captured in the lagoon in December, after a large flood on the 9th of December.

Juvenile coho were collected at all 12 sites sampled in the Scott

Creek watershed in 1996 (Table 4). Estimated overall density in sampled habitats was 33.0 per 100 feet of stream, slightly higher than the 27.3 estimated for January 1994 (Table 6). Lowest density (11 per 100 feet) was on Big Creek (Site 12B), in the bedrock/large cobble channel upstream of the hatchery (Table 4); the similar, uppermost site on Scott Creek had a much higher density of 31 coho per 100 feet. Highest densities (62 per 100 feet) were at sites 7 and 9 on Scott Creek (Table 4), which are located immediately downstream of a seasonal tributary used by spawning coho. At the remaining sites densities were reasonably similar (21 to 37 per 100 feet)(Table 4), even for the two downstream sites, which received fry plants.

Coho and steelhead were present in the lagoon of Scott Creek in early summer, but the sand bar formed, rapidly filled, and breached numerous times over the summer. Unlike at Waddell Creek, when the sandbar breached at Scott Creek in 1996 almost no deepwater habitat existed; shallow streambed extended all the way to the surf, and few coho or steelhead survived the summer.

Coho were collected at all five sites sampled on Gazos Creek (Table 5), although they were relatively rare (0.6-0.9 per 100 feet) at the two sites downstream of Old Woman Creek. No coho were captured in a spot check of the lower 200 feet of Old Woman Creek. Densities at the three sites upstream of Old Woman Creek were estimated at 7-8 coho per 100 feet of habitat sampled (Table 5), but overall density for the five Gazos Creek sites was only 4.9 coho per 100 feet (Table 6). Coho density was no more than 1/4 that of YOY steelhead at any site (Table 5).

Coho sizes at each site on the three streams averaged 5-10 mm smaller than in 1995 (Figures 1 and 2; Smith 1995b). Largest coho were in the main stem of Waddell Creek (Figure 1) and in Scott Creek downstream of Big Creek (Figure 2). Sizes decreased upstream and in tributaries of both watersheds (Figures 1 and 2). Sizes of coho on Gazos Creek were similar to those on upper Scott Creek and on the West Fork of Waddell Creek (Figure 1).

Steelhead

Estimated YOY steelhead density at Waddell Creek sites averaged 62 fish per 100 feet, but varied substantially among sites (Table 3). Lowest densities (28-39 per 100 feet) were on the East Fork, on the West Fork downstream of Slippery Falls, on the main stem immediately downstream of the confluence of the two forks, and on Henry Creek (Table 3). Other main stem sites and the site upstream of Slippery Falls had substantially higher densities (69-155 per 100 feet). Overall YOY densities have been similar in all study years (Table 7). Yearling steelhead averaged 15 fish per 100 feet, but ranged from 7-31 per 100 feet at the diffferent sites (Table 3).

The sand bar at Waddell Creek lagoon closed briefly for only several days during the summer, and degree of salinity, temperature and oxygen stratification and lagoon depth fluctuated with tidal cycles throughout the summer. Juvenile steelhead grew quickly during the early summer, but growth of larger fish slowed after July. The lagoon steelhead population in July was estimated at approximately 6600, based upon fish marked on 11 July and recapture ratios on 25 July. By 28 September most of these fish, predominantly YOY, were the size of stream yearlings (Figure 3). After early storms in November some smaller stream steelhead moved into the lagoon. After the heavy early December storm none of the smaller steelhead were apparently still present in the lagoon, and the population of larger, lagoon-reared fish was substantially reduced.

YOY steelhead on Scott Creek averaged 35 per 100 feet of sampled habitat, and only one site exceeded the mean for Waddell Creek (Tables 4 and 7). YOY densities were substantially below those of 1995 (Table 7). However, yearling steelhead densities have been relatively stable for the past 5 years (Table 7). Only 4 hatchery-origin holdover yearlings were collected in 1996.

YOY steelhead on Gazos Creek averaged 34 per 100 feet of sampled habitat (Table 5), with the lowest densities in the densely-shaded downstream sites. Substrate at the three downstream sites was also coated with fine silt, especially downstream of Old Woman Creek. As in Scott Creek, YOY density was substantially reduced from 1995, but yearling densities have been relatively stable (Table 7). Both YOY and yearling steelhead were present in tiny Old Woman Creek, although density was very low (approximately 12 per 100 feet) and fine silt coated the streambed.

As was also found for coho, steelhead were largest on the main stem of Waddell Creek (Figure 3) and on Scott Creek downstream of Big Creek (Figure 4). Sizes were smaller on the East and West Forks of Waddell Creek, on Gazos Creek, and on upstream and tributary sites in the Scott Creek watershed (Figures 3 and 4). Sizes of YOY fish averaged somewhat smaller (5 mm) than in 1995 at Waddell Creek sites (Figure 3 and Smith 1995b). Sizes for Scott and Gazos Creek fish were similar to those of 1995 (Figures 3 and 4 and Smith 1995b).

Electroshock Mortality

Overall 1996 mortality for captured steelhead and coho on these three streams and on Redwood Creek in Marin County was 0.9 % (Table 8). Lowest mortality was for yearling steelhead (0.1%), and highest was for coho (1.4%). Mortality was highest during August and September on Waddell, when water temperatures were highest; no mortality occurred on the same stream in November (Table 8). Coho mortality was highest on Waddell Creek, where deeper pools were sampled, and lowest on Gazos Creek, where pools were generally smaller and shallower and water temperatures were low.

DISCUSSION

Coho

Major runs of adult coho occurred on Scott and Waddell creeks in winter 1995-6. For Waddell Creek the run by early January probably exceeded 120 fish, including perhaps half hatchery-reared fish straying from Scott Creek or stocked as smolts in Waddell Creek in 1994. Based upon wild and hatchery production in 1993 (Smith 1994a), Scott Creek probably had an adult run at least 3 times as large. Juvenile abundances in Waddell, Scott and Gazos creeks in 1996 reflect adult run sizes, losses due to storm runoff and the effects of plants of hatchery fry.

Waddell Creek. Coho were not collected above Slippery Falls in 1992, 1993 or 1996 so either the falls is normally a barrier to coho or the habitat above suffers redd destruction in years when flows are sufficient to allow coho passage. Spawning can apparently be heavy in Henry Creek, just downstream of Slippery Falls (Table 1), however no juvenile coho were found in the tributary in 1992 or 1995, years of severe February or March floods. In 1996 only 2 young coho were found amid evidence of severe channel alterations from winter floods. Densities were also relatively low in 1993 and 1996 at Site 11 on West Fork Waddell Creek (just downstream of Henry Creek) and at the upper site on East Fork Waddell Creek (Table 9); both sites are predominantly bedrock or boulders and subject to scour from winter floods.

Coho were reasonably common at the other West Fork and East Fork sites in 1996 (Table 3), with coho about half as abundant in sampled habitats as YOY steelhead. Significant coho production would probably have occurred in 1996, even without the plants of fry. However, the relative contributions of wild production versus fry plants downstream of the East and West Fork confluence are difficult to separate. In 1993 most juvenile coho were in the West Fork and in the upper 1 mile of the main stem (Table 9); because of limited spawning potential in flood years on the main stem, it is likely that the most of the main stem coho juveniles had dispersed downstream from the West Fork. In 1996 substantial spawning took place throughout the West Fork and main stem (Table 1), but it appears that many of those redds at sandier downstream habitats were destroyed. It's likely that in 1996 many of the coho at upstream main stem sites (4-6) were due to natural spawning, as in 1993 (Table 9). However, coho at the downstream sites (1-3) were probably the result of plants of hatchery fry. Despite the uncertainty about the relative roles of fry plants, spawning by hatchery smolts planted in 1994, and spawning by wild-reared fish, Waddell Creek did manage to support a substantially increased population of juvenile coho in 1996 (Table 6). That still leaves Waddell Creek with only 1 relatively strong year class, one very weak one (1995), and one year class gap (1994) (Table 6).

In Spring 1997 Waddell Creek is scheduled to receive hatchery-reared smolts from Big Creek (Patricia Anderson, letter of 17 April). About 2/3 of the fish are to large smolts (6/lb), a portion of which should return precocially to augment the weak 1995 year class.

Of particular interest is the lack of significant coho presence in Waddell Creek lagoon in 1996. In previous years the absence could be explained by the scarcity of coho in the lower two miles of stream (Smith 1992, 1995; Smith and Davis 1993). In 1996, however, coho fry were planted within 1/4 mile of the upper end of the lagoon and heavy May streamflows should have provided for easy dispersal to the lagoon. Coho were present at a relatively high density immediately upstream of the lagoon in September (Table 3). It may be that the fluctuating nature of salinity and temperature stratification in the open lagoon prevented coho use.

Scott Creek. Winter and spring storms in 1995-96 apparently did not significantly affect coho density in the Scott Creek watershed, as significant numbers of coho were found at all sites. Coho were even common at the steep uppermost site on Scott Creek, and in the bedrock pool at the uppermost Big Creek site (Tables 4 and 10). By comparison, the 1993 year class had much lower densities on Big Creek, Mill Creek and the upper site on Scott Creek (Table 10).

Despite the relatively large adult coho run in Scott Creek in 1995-96, overall juvenile density was not much greater than in 1993 (Tables 6 and 10). For the flatter habitats upstream of Little Creek (Sites 2-11), the densities were actually higher for 1993 (49 per 100 feet in 1993 and 45 in 1996) (Table 10). The lower overall density in 1993 can be accounted for by lower densities at the steepest sites (due to heavy winter runoff) and by low densities downstream of Little Creek (probably due to lack of spawning success in the sandy substrate). In 1996 the plants of fry in the lower 2 miles of Scott Creek appear to account for the high densities there compared to other years (Table 10).

The close density agreement between 1993 and 1996 for many of the sites may indicate that these densities are close to juvenile coho carrying capacity. If the highest densities recorded at each site in any year (Table 10) are averaged, the overall density would be 38 coho per 100 feet, not much greater than the 1996 density of 33 per 100 feet. Coho densities on Redwood Creek, which has much better substrate quality (less sand), have ranged from 39 to 46 coho per 100 feet in years when spawning has been adequate (Table 6 and Smith 1996).

In 1995 a heavy flood occurred in March; almost no juvenile coho were present in Big Creek, and the upper 3 sites on Scott Creek had very low densities (Table 10). The lower juvenile coho densities in 1995, compared to both 1993 and 1996, may have been substantially due to the effects of the March flood.

The priority for coho restoration on Scott Creek appears to be the rebuilding of the weak 1994/1997 brood year. The other two brood years now appear to be strong, with the recovery of the 1995 year class apparently due to precocial return of hatchery-reared females (Smith 1995b). Some precocial hatchery-reared females may return in 1996-97 to bolster the 1997 year class. Otherwise, hatchery augmentation of the 1997 is a possibility, although few females are likely to be available for either wild or hatchery spawning in 1996-97. Another alternative is to rear hatchery-spawned fish to large size in 1998 in order to produce precocial returns of females. The second alternative would have less impact on wild production.

In spring 1997 large (6/lb) hatchery-reared smolts are scheduled for release in Scott Creek (Patricia Anderson, letter of 17 April). A portion of these bigger fish should return precocially and boost the weaker 1995 year class. Additional, "normal-sized" smolts are also scheduled for release. The abundance of wild fish in 1996 indicates that supplementation may not needed, and those fish could be used elsewhere (such as to augment small runs on Pescadero or San Vicente creeks or to restore coho to San Gregorio Creek).

Gazos Creek. Despite the planting of approximately 7000 coho fry on Gazos Creek in April and May, fall coho density in 1996 was low compared to Waddell and Scott creeks (Table 6), and not dramatically higher than for the 1993 year class. The densities between the two years are not directly comparable, as additional riffle and shallow glide habitats, which lack coho, were added to the sampling in 1996. With the added habitats removed, the comparable coho density would be about 7-8 coho per 100 feet, more than a tripling of coho compared to 1993, but still substantially lower than on Waddell or Scott creeks.

Twelve of 14 fry plants on Gazos Creek were upstream of Old Woman Creek (Patricia Anderson, letter of 14 March), and only 3 of the 33 coho captured on Gazos Creek were from the two sites downstream of Old Woman Creek. Pool development and escape cover are as good downstream of Old Woman Creek as at the upstream sites, but fine sediment on the lower portion of the stream, including apparently large amounts of sediment from Old Woman Creek, are a probably a significant problem for food production. The sediment may also be a factor in spawning success downstream of Old Woman Creek.

The 1996 year class has been strengthened by the fry plants, but it is presently the only viable year class on Gazos Creek (Table 6). In Spring 1997 both regular and large (6/lb) Big Creek Hatchery smolts are scheduled for release in Gazos Creek (Patricia Anderson, letter of 17 April) to augment the 1996 year class and to provide precocial females to boost the almost non-existent 1995 year class.

Steelhead

Steelhead populations are apparently healthy on all three streams. Overall steelhead abundance on Waddell Creek has been relatively consistent among the years (Table 7). However, the densities at individual sites has fluctuated much more dramatically, especially on the main stem (Smith 1994c, 1995; Smith and Davis 1993). Although higher streamflows might be expected to support more steelhead, the more pronounced effect of wet years on YOY steelhead in Waddell Creek has been to increase fish size (Smith 1994c, 1995).

In contrast to Waddell Creek, overall densities of YOY steelhead on Gazos and Scott creeks varied significantly among years. On Scott Creek steelhead density in sampled habitats appears to have been reduced by either high coho abundance or low summer streamflow. In 1992 streamflows were near-average, but coho, who compete for pools, were rare; YOY steelhead were abundant (Tables 6 and 7). In 1993 and 1996 streamflows were high, but abundant coho dominated pools and YOY steelhead were relatively scarce. In 1995 summer streamflows were high and coho were intermediate in abundance; YOY steelhead were abundant. In 1994 streamflows were quite low, but coho were also very scarce; steelhead density was intermediate. In Gazos Creek coho are too rare to affect steelhead abundance, and abundance appears to reflect streamflow and sediment conditions; Old Woman Creek appears to be a major source of fine sediment for lower Gazos Creek and may be a factor in steelhead spawning and rearing success on lower Gazos Creek.

A major variable in steelhead production on Waddell Creek is the year-to-year suitability of the lagoon for rearing. In 1996 the lagoon reared an estimated 6600 steelhead to yearling size by September. Most of these lagoon fish were YOY, but their sizes (Figure 3) and numbers exceeded the steelhead yearlings in the remaining accessible habitat (8 miles) in the Waddell Creek Watershed.

At Scott Creek the sand bar was repeated breached in 1996, eliminating it as a signifcant rearing habitat for steelhead and also probably reducing the value of the adjacent marshlands for reptiles and amphibians. The lack of depth of the Scott Creek stream mouth when the sand bar is open also precludes a brackish estuarine transition zone for outmigrating coho and steelhead smolts in spring; this may significantly reduce survival of small smolts during their transition to salt water.

Electroshock Sampling

The Coho mortality for habitats sampled on Waddell Creek was 1.7% overall (Table 8), but was higher for individual deep, complex habitats. Since only 6-7 percent of the habitat accessible to coho was sampled, the loss to the 1996 Waddell Creek coho population was approximately 0.1-0.2%. Mortality rate was lower for steelhead and for coho on Gazos and Scott creeks, which are generally shallower and had lower water temperatures at the time sampling. In addition, only 2-4 % of the habitat was sampled on those streams, so population loss was much less than 0.1 %. Loss can also be reduced by using live cars, lowering voltage levels in shallow water, and sampling later in the year.

Electroshock sampling has provided important year-to-year indices of coho and steelhead abundance in these three streams and should be continued. Steep headwater sites on the streams have been subject to varying degrees of flood damage, and downstream sites tend to be sandy with poor spawning. Sampling a large number of sites is necessary to bracket the range of channel conditions on each stream. In addition, in years of low coho abundance their distribution can be very patchy (Smith 1992, 1994b, 1994c); sampling a large number of sites is necessary to locate localized concentrations. If sampling intensity were to be reduced, reduction of the number of habitats sampled at each site would be a better strategy than reducing the number of sites. However, major changes in sampling intensity might reduce the comparative value of the index.

Direct observation was tried on Scott and Waddell creeks in 1988 (Smith 1994c) and very poorly correlated with electroshocker sampling. Pools in Scott Creek are small and complex, and visibility in Waddell Creek was limited by bluish water color by mid summer. Dense shade at many sites limited visibility for most of the day. Depth limited direct observation in shallower glides, which are used by coho when densities are high.

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Table 1. Coho sightings, carcasses, and redds by reach in Waddell Creek for 5-12 January 1996.

Reach	Carcasses	Fish	Redds	Fish/mi	Redd/mi
Mile 0.4 to 0.6 Footbridge-1st Bridge		1	4	5	20
Mile 0.6 to 1.05 1st to second bridge	2	1	9	2.2	20
Mile 1.05 to 1.35 (<Alder Camp)		4	6	13.3	20
Mile 1.35 to 1.50 (Alder Camp)		1	1	6.7	6.7
Mile 1.5 to 1.85 (Twin Redwoods Camp)		9	6	25.7	17.1
Mile 1.85 to 2.25 (Periwinkle)		11	6	27.5	15
Mile 2.25 to 2.60 (Pullout < Herbert)	1	5	2	14.7	5.7
Mile 2.60 to 3.1 (Camp Herbert)	1	12	2	24	4
W Fork Mile 3.1 to 3.5	1	7	4	17.5	10
WF Mile 3.5 to 3.9 (Mill Site)	1	4	4	10	10
WF Mile 3.9 to 4.3		9	7	22.5	17.5
WF Mile 4.3 to 4.7 (Buck Creek)		8	5	20	12.5
WF Mile 4.7 to 5.35 (Slippery Falls)	1	8	4	12.3	6.2
Henry Creek Mile 0 - 0.25		1	3+	4	12
East Fork Mile 0 - 0.2		1	3	4	15
EF Mile 0.2 - 0.7		0	0	0	0
Totals	7	82	66		
subtotal Main Branch	4	44	36	15.2	12.4
subtotal E. Fork		1	3	1.4	4.3
subtotal W. Fork/Henry	2	37	27	14.8	10.8

Table 2. Composition of coho observed or recovered on Waddell Creek, 29 December - 12 January.

Composition	Male			Female			?
	Wild	?	Hatchery	Wild	?	Hatchery	
Lagoon (Seine)	2		2	6		4	
Carcasses	1		2	3		1	
Observations							
Main Branch	7	5	1	1	9	2	20
East Fork					1		
West Fork	5	9	2	3	6	2	10
Total	15	14	7	13	16	9	30
	----- 36 -----			----- 38 -----			

*"Hatchery" fish were definitely missing right pelvic fins; many of the "wild" fish are also probably of hatchery origin.

Table 3. Site locations, habitat types present and sampled, number of steelhead and coho collected and estimated density per 100 feet () at sites on Waddell Creek in August and September 1996. (site #s agree with earlier reports).

Site	Mile >Hwy1	Chan Type	%Hab Avail PL	GL	RN	RF	%Hab Sampl PL	GL	RN	RF	Sample Length	#SHT 0+	1+	COHO
1 >Div	0.6	C4	43	35	15	7	71	29	-	-	180'	124 (69)	33 (23)	29 (16)
2 <Alder Camp	1.35	C4	45	35	10	10	71	29	-	-	239	268 (114)	33 (14)	11 (7)
3 Twin Redwoods	1.8	C4	40	45	10	5	75	13	6	6	226	142 (67)	35 (16)	28 (14)
4 Peri-winkle	2.2	C4	35	40	20	5	65	35	-	-	113	131 (120)	35 (35)	31 (30)
5 Pullout <Herbert	2.6	C3	45	25	20	10	63	27	6	4	203	137 (78)	20 (11)	30 (16)
6 Camp Herbert	3.1	C3	45	25	20	10	89	4	8	-	228	81 (36)	25 (11)	35 (15)
7 E Fork > Ford	3.2	C3	45	25	20	10	74	18	9	-	205	54 (33)	29 (16)	19 (10)
14 E Fork	3.7	B2 B1	35	10	35	20	99	1	-	-	105	37 (39)	10 (12)	3 (4)
8 W Fork	3.3	C4	35	35	20	10	48	26	14	12	232	53 (29)	19 (9)	27 (13)
9 Mill Site	3.9	C4	45	30	15	10	76	21	3	-	173	47 (37)	11 (7)	38 (23)
10 Trib @ Bridge	4.7	C1 C3	40	30	20	10	56	29	15	-	236	82 (36)	26 (11)	36 (18)
11 HenryCr Trail	5.25	B1	35	25	25	15	62	35	4	-	200	53 (28)	18 (10)	13 (7)
Slippery Falls	5.35													
12 Upper Bridge	5.45	B1	30	25	25	20	79	-	13	7	72	93 (155)	22 (31)	0 -
13 HenryCr >Trail	0.2	F	45	10	25	20	34	34	32	-	79	24 (31)	7 (9)	2 (3)
Totals											2491'	1326	323	302
Mean of 14 Sites			40	29	20	12	69	21	8	2		(62)	(15)	(13)

Table 4. Site locations, habitat types present and sampled, number of steelhead and coho collected and estimated density per 100 feet () at sites on Scott Creek in October and November 1996. (Site #s agree with earlier reports).

Site	Mile >Hwy1	Chan Type	%Hab Avail PL	GL	RN	RF	%Hab Sampl PL	GL	RN	RF	Sample Length	#SHT 0+	1+	COHO
A Near Diversion	0.9	C4	40	40	15	5	61	29	11	-	157'	33 (23)	39 (25)	21 (22)
1 <Little Creek	1.9	C3	40	35	15	10	62	34	2	1	180	46 (26)	40 (22)	58 (33)
Big Creek	2.15													
2 Pullout >Big Cr.	2.55	C4	40	35	20	5	74	19	8	-	161	40 (32)	36 (23)	47 (31)
4 <Swanton Road	3.55	C4	35	45	15	5	64	28	8	-	192	34 (18)	31 (16)	71 (37)
7 Pullout <Big Cr. Gate	4.9	C4	35	35	23	7	46	43	10	-	97	33 (38)	21 (24)	52 (62)
9 0.15 mi > bridge	5.15	C4	30	35	25	10	49	41	6	4	78	37 (50)	8 (10)	37 (62)
11 Upper Ford	5.85	C3	45	40	10	5	65	25	8	2	197	44 (25)	16 (9)	61 (33)
11A 4th Trail Xing	6.5	B3 B1	35	10	40	15	66	23	11	-	140	47 (37)	37 (31)	39 (31)
12 Big Cr. Swanton Rd.		C3	20	20	35	25	51	49	-	-	117	18 (20)	12 (10)	20 (21)
12A Big Cr. Below Hatchery		B3	25	10	50	15	57	43	-	-	70	44 (65)	21 (31)	18 (30)
12B Big Cr. >Berry Cr.		B1 B2	50	5	30	15	73	3	19	5	146	66 (50)	40 (28)	16 (11)
13 Mill Cr. <Swanton Rd.		C3	45	25	15	15	71	18	11	-	149	48 (35)	21 (14)	33 (24)
Totals Mean of 12 Sites			37	28	25	11	62	30	8	1	1684'	490 (35)	322 (20)	473 (33)

Table 5. Site locations, habitat types present and sampled, number of steelhead and coho collected and estimated density per 100 feet () at sites on Gazos Creek in September 1996.

Site	Mile >Hwy1	Chan Type	%Hab Avail PL	GL	RN	RF	%Hab Sampl PL	GL	RN	RF	Sample Length	#SHT 0+	1+	#Coho
1	0.9	C4	30	25	30	15	39	32	18	11	169	30 (21)	22 (13)	1 (0.6)
2	1.8	C4	25	25	35	15	45	30	7	19	232	64 (28)	26 (11)	2 (0.9)
Old Woman Creek	2.05													
2A	2.1	C4	30	30	25	15	48	31	17	5	65	20 (31)	9 (14)	5 (8)
3	3.15	B4	35	15	30	20	60	13	15	11	187	82 (44)	19 (10)	12 (7)
4	4.4	B4	20	35	25	20	51	29	3	17	177	68 (46)	15 (9)	13 (8)
Totals:											830'	262	91	33
Mean of 5 Sites			28	26	29	17	49	27	12	13		(34)	(12)	(4.9)

Table 6. Number of sites, amount and type of habitat sampled, number of coho collected and estimated density (per 100 feet) for Gazos, Scott, Waddell and Redwood creeks in 1988, 1992, 1993, 1994, 1995 and 1996.

Stream and Date		Number of Sites Sampled	Length (feet)	Habitat Pl	Gl	Percent Rn	RF	% Sites w/coho	Coho #	Dens. (/100')
<u>Gazos Creek</u>										
Aug	1992	2	275	44	56	0	0	0	0	0
Jan	1994	4	503	65	22	12	1	50	9	2.2
Nov	1995	4	425	58	19	21	3	25	1	0.2
Sep	1996	5	830	49	27	12	13	100	33	4.9
<u>Scott Creek</u>										
Jul-Sep	1988	14	3535	41	25	21	12	84	384	15.5
Aug-Oct	1992	13	1624	66	30	4	0	46	42	4.3
Jan	1994	11	1554	49	32	19	0	100	376	27.2
Aug	1994	13	1744	59	36	6	0	46	17	1.1
Oct	1995	12	1686	59	32	8	1	92	223	14.2
Oct-Nov	1996	12	1684	62	30	8	1	100	473	33.0
<u>Waddell Creek</u>										
Jun-Aug	1988	8	1817	54	19	23	5	63	19	1.3
Jul-Aug	1992	13	2858	67	31	2	0	38	19	0.6
Oct/Dec	1993	12	1857	38	21	28	14	75	58	3.6
July	1994	12	2367	66	24	7	2	0	0	0
Sep	1995	12	2498	64	24	10	2	58	24	1.1
Aug-Sep	1996	14	2491	69	21	8	2	93	302	12.5
<u>Redwood Creek</u>										
Jun-Sep	1992	4	1032	37	40	5	7	100	426	45.3
Jun-Aug	1993	4	951	48	25	18	9	100	355	46.3
July	1994	7	1287	58	25	12	6	43	24	1.9
Aug	1995	4	796	41	30	19	10	100	308	42.0
Nov	1996	3	604	51	31	11	7	100	214	38.8

Table 7. Number of sites, amount and type of habitat sampled, and estimated density (per 100 feet) of steelhead for Gazos, Scott, Waddell and Redwood creeks in 1988, 1992, 1993, 1994, 1995 and 1996.

Stream and Date		Number of Sites Sampled	Length (feet)	Habitat Percent Pl	Gl	Rn	RF	Density Age 0+	Age 1/2+
Gazos Creek									
Aug	1992	2	275	44	56	0	0	24	12
Jan	1994	4	503	65	22	12	1	29	9
Nov	1995	4	425	58	19	21	3	68	14
Sep	1996	5	830	49	27	12	13	34	12
Scott Creek									
Jul-Sep	1988	14	3535	41	25	21	12	57	7
Aug-Oct	1992	13	1624	66	30	4	0	89	21
Jan	1994	11	1554	49	32	19	0	39	21
Aug	1994	13	1744	59	36	6	0	52	18
Oct	1995	12	1686	59	32	8	1	90	10
Oct-Nov	1996	12	1684	62	30	8	1	35	20
Waddell Creek									
Jun-Aug	1988	8	1817	54	19	23	5	45	7
Jul-Aug	1992	13	2858	67	31	2	0	56	10
Oct/Dec	1993	12	1857	38	21	28	14	54	8
July	1994	12	2367	66	24	7	2	61	19
Sep	1995	12	2498	64	24	10	2	79	14
Aug-Sep	1996	14	2491	69	21	8	2	62	15
Redwood Creek									
Jun-Sep	1992	4	1032	37	40	5	7	23	4
Jun-Aug	1993	4	951	48	25	18	9	56	4
Oct	1994	5	1018	83	10	4	3	34	6
Aug	1995	4	796	41	30	19	10	96	4
Nov	1996	3	604	51	31	11	7	33	11

Table 8. Fish killed and captured (/) and mortality rate (%) for juvenile steelhead and coho captured by electroshocking on Waddell, Scott, Gazos and Redwood creeks in August - November 1996.

	Steelhead				Coho	
	Age 0+ Kill/Capt	%	Age 1+ Kill/Capt	%	Age 0+ Kill/Capt	%
<u>Waddell Creek</u>						
Aug-Sep	17/1326	1.3	0/323	0	5/302	1.7
Nov	0/239	0	0/49	0	0/88	0
<u>Scott Creek</u>						
Oct-Nov	4/490	0.8	0/322	0	5/473	1.1
<u>Gazos Creek</u>						
Sep	3/262	1.1	1/91	1.1	0/33	0
<u>Redwood Creek</u>						
Nov	0/196	0	0/63	0	2/214	0.9
Totals	24/2513	1.0	1/848	0.1	12/840	1.4
Overall			37/4201	0.9		

Table 9. Site locations and habitat types sampled and coho densities (/ 100') in October 1993 (*=July,**=December) and August-September 1996 on Waddell Creek.

Site	Mile >Hwy1	1993 %Hab Sampl PL	GL	RN	RF	1993 Coho Density	1996 %Hab Sampl PL	GL	RN	RF	1996 Coho Density
1 >Div*	0.6	32	32	36	-	1	71	29	-	-	16
2 <Alder Camp	1.35	30	29	41	-	0.3	71	29	-	-	7
3 Twin Redwoods	1.8	40	-	29	31	0	75	13	6	6	14
4 Peri-winkle	2.2	32	-	42	26	4	65	35	-	-	30
5 Pullout <Herbert	2.6	23	17	22	38	4	63	27	6	4	16
6 Camp Herbert	3.1						89	4	8	-	15
7 E Fork > Ford	3.2	33	6	61	-	2	74	18	9	-	10
14 E Fork**	3.7	50	7	44	-	4	99	1	-	-	4
8 W Fork	3.3	43	33	6	18	7	48	26	14	12	13
9 Mill Site	3.9	35	25	29	11	4	76	21	3	-	23
10 Trib @ Bridge	4.7	19	-	53	28	0	56	29	15	-	18
11 HenryCr Trail	5.25	40	36	-	24	2	62	35	4	-	7
Slippery Falls	5.35										
12 Upper Bridge	5.45	99	-	-	-	0	79	-	14	7	0
13 HenryCr >Trail	0.2	-	99	-	-	16	34	34	32	-	3
Means		38	21	28	14	3.6	69	21	8	2	12.5

Table 10. Site locations and coho densities (/ 100') in January 1994 (1993 Year Class), October 1995 and October and November 1996 on Scott Creek.

Site	Mile >Hwy1	Year Class Density 1993	1995	1996
A Near Diversion	0.9	1.9	1.2	22
1 <Little Creek	1.9	7	14	33
Big Creek	2.15			
2 Pullout >Big Cr.	2.55	31	29	31
3. < Mill Creek	3.05		28	
4 <Swanton Road	3.55	86	26	37
7 Pullout <Big Cr. Gate	4.9	48	23	62
9 0.15 mi > bridge	5.15	39	12	62
11 Upper Ford	5.85	41	5	33
11A 4th Trail Xing	6.5	16	2.6	31
12 Big Cr. Swanton Rd.		8	1.0	21
12A Big Cr. Below Hatchery		9	0	30
12B Big Cr. >Berry Cr.				11
13 Mill Cr. <Swanton Rd.		12	28	24
Mean		27.2	14.2	33.0

Figure 1. Standard lengths (mm) of coho from Waddell and Gazos creeks in August and September 1996. Sizes for Waddell Creek sites 1-4 were typical of main stem sites (1-6); sizes for West Fork sites 8-11 were also typical of East Fork sites (7 & 14).

Standard Lengths	Waddell Creek Sites 1-4 (n=99)	WF Waddell Creek Sites 8-11 (n=114)	Gazos Creek (n=33)
40 - 44			1
45 - 49		2	*3
50 - 54		*******22	*3
55 - 59	*5	************38	****9
60 - 64	*****15	**********31	**5
65 - 69	*******22	*********28	****9
70 - 74	************32	2	*2
75 - 79	****14		
80 - 84	**6		

Figure 2. Standard lengths (mm) of coho from Scotts Creek watershed in October and November 1996. Sizes for sites 11 & 11A were also typical of sites on upper Scott Creek (7,9) and on Mill Creek (13).

Standard Lengths	Scott Cr. Sites A&1 (n=79)	Big Creek (n=54)	Scott Cr. Sites 2&4 (n=118)	Scott Cr. Sites 11&11A (n=100)
40 - 44				*3
45 - 49			*4	***11
50 - 54			*******22	*********29
55 - 59	*3	*5	***********34	**********30
60 - 64	***11	***10	********24	******20
65 - 69	*******21	*******22	*****15	**6
70 - 74	******19	*****16	***9	
75 - 79	***10	2	1	
80 - 84	****12			
85 - 89	2			

Figure 3. Standard lengths (mm) of Steelhead from Gazos Creek, Waddell Creek, West Fork Waddell Creek and from the Waddell lagoon in August and September 1996. Waddell Site 1 sizes were typical of main stem sites (2-6); Sites 8 & 9 were typical of the sites on the East and West Forks.

Standard Lengths	-----Waddell Cr.------ Site 1 (n=69)	Sites 8 & 9 (n=66)	Gazos Cr. Sites 2A-4 (n=121)	Waddell Cr. Lagoon (n=337)
30 - 34		*4		
35 - 39	1	**11	**8	
40 - 44	*4	*****17	******20	
45 - 49	**7	*****16	**********30	
50 - 54	****14	*****15	********25	
55 - 59	******19	***11	**********30	
60 - 64	*****15	*****15	****13	1
65 - 69	****13	**8	***10	1
70 - 74	***9	*5	**6	4
75 - 79	**8	2	*4	*6
80 - 84	*3	*3	***9	3
85 - 89	2	*5	2	*5
90 - 94		*3	2	*5
95 - 99	*3	*4	**6	***15
100-104	2	*4	2	*****25
105-109	2	1	*3	**10
110-114	*4	1	2	***17
115-119	*3	1	2	******31
120-124	*3	2		******34
125-129	*3	1	1	******33
130-134	*3		1	*********49
135-139	*5	1		*********47
140-144	2	1		*****28
145-149				**13
150-154	1			4
155-159	1			4
160-164				2

Figure 4. Standard lengths (mm) of steelhead from Scott Creek in October and November 1996. Sizes for sites 2 & 4 were also typical of Big Creek; sizes for sites 9 & 11 were typical of sites on upper Scott (7-11A) and on Mill Creek (13).

Standard Length	Sites A & 1 (n=158)	Sites 2 & 4 (n=141)	Sites 9 & 11 (n=105)
35 - 39			*****10
40 - 44	*2	***7	*******15
45 - 49	*3	**5	********16
50 - 54	***7	*****10	*******15
55 - 59	**5	*****11	****8
60 - 64	*********18	******12	**5
65 - 69	******13	******12	**7
70 - 74	*****10	****9	**4
75 - 79	***7	****9	*2
80 - 84	****9	*3	***6
85 - 89	*****10	*****10	*2
90 - 94	******13	*****11	1
95 - 99	****9	******12	*3
100-104	***7	****8	1
105-109	**5	*3	1
110-114	****8	*3	*2
115-119	***7	*2	*2
120-124	*3	*2	1
125-129	**4	*2	
130-134		***6	1
135-139	**5		1
140-144	**4		
145-149	*2		
150-154			
155-159			
160-164	*2		
165-169	1		