# STANISLAUS RIVER SALMONID DENSITY AND DISTRIBUTION SURVEY REPORT (2000-2001)

(FINAL DRAFT)

Prepared by
Trevor Kennedy, Senior Fishery Biologist
and
Thomas C. Cannon, Executive Director
Fishery Foundation of California

Prepared for
The U.S Fish and Wildlife Service
Central Valley Project Improvement Act Program

December, 2002

# Table of Contents

# Stanislaus River Anadromous Fish Surveys 2000-2001


## Abstract

Snorkel surveys were conducted on the lower Stanislaus River during 2000-2001 to determine the distribution, abundance, and habitat use patterns of juvenile Chinook salmon and rainbow trout. Young Chinook salmon were abundant in late winter and spring throughout most of the river from Goodwin Dam downstream to Oakdale. Their distribution shifted downstream through the spring and their numbers declined sharply from mid April to mid May coincident with the Vernalis Adaptive Management Program experimental storage releases from New Melones Reservoir. We speculate that that VAMP flows encouraged the young salmon to leave the river and migrate to the estuary. Young trout were abundant from late spring through the fall throughout the river in 2000; however, in 2001 their abundance was more confined to the upper portion of the river under lower flows than 2000. Yearling trout were concentrated in the upper portion of the river below Goodwin Dam where summer water temperatures were consistently below 16$^{o}$C, whereas downstream temperatures reached 18-20$^{o}$C. Young salmon and young and yearling trout were found in significantly higher densities in experimental sites where gravel had been placed in the river to create riffle habitat. Small numbers of adult salmon were observed during the summer, including several in June that had recently spawned. Yearling Chinook were observed in low numbers over summering in the river upstream of Lovers Leap. Striped bass and American shad adults were also observed in the lower reaches during the summer, and were potential predators on young salmon and trout.


## Introduction

In January 2000, the Fishery Foundation of California (Foundation) entered into a cooperative agreement with the US Fish and Wildlife Service to monitor Chinook salmon and rainbow/steelhead trout via snorkel surveys within the lower Stanislaus River in years 2000 and 2001. The Central Valley Project Improvement Act (CVPIA) provided funding. New Melones Dam on the Stanislaus River is part of the Central Valley Project. The CVPIA provides for the mitigation, protection, and restoration of fish and wildlife resources and associated habitats within California's Central Valley. This report documents the results of the surveys in 2000 and 2001. Observations and data are summarized below. Detailed data are presented in the appendix.

### Purpose

The purpose of the investigation was to survey spatial and temporal distribution and abundance and habitat use by juvenile salmonids within the lower Stanislaus River. The information will assist in implementing the CVPIA activities related to determining water needs for the Stanislaus River. Specifically, the snorkel surveys help in determining habitat use patterns of juvenile salmonids under different flow regimes that occur over the year. Understanding what habitats juvenile salmonids seek out will help determine habitat restoration needs. Understanding how juvenile salmonids respond to specific flow changes will help in evaluating the importance of flow in triggering emigration patterns. CVP actions to improve salmon and steelhead populations in the Stanislaus River include habitat improvements and "fish friendly" flow releases from New Melones Dam. The snorkel survey was intended to observe responses to these fish actions to evaluate the benefits of such actions

## Objectives/Questions Addressed by Study

- Collect information on the life history of anadromous salmonids in the lower Stanislaus River.
- Determine the seasonal distribution and relative abundance of juvenile salmonids.
  - How are Chinook salmon and trout distributed within the Stanislaus River?
  - Are certain reaches or habitat types utilized disproportionately?
  - Do juvenile Chinook salmon and trout shift their distribution within the river in response to changes in habitat conditions (temperature, flow, predators, competitors, physical habitat, etc)?
- Collect information that can be used to evaluate the need for and benefits of habitat restoration.
- Collect information that can be used to evaluate restoration projects.
- Relate distributions and relative abundance of different life stages of juvenile salmonids and other fishes to habitat conditions (water temperature, turbidity, velocity, cover, vegetation, substrate, geomorphology, predators, aquatic invertebrates, etc).
  - What habitat factors relate to fish distribution and habitat use?
  - How do juvenile Chinook salmon respond to changes in flow and water temperature?
- Document changes in juvenile salmonid distribution and abundance patterns as a consequence of supplemental spring flows of the Vernalis Adaptive Management Program (VAMP).
- Develop conceptual models of the life history, distribution and relative abundance, and habitat use patterns of juvenile salmonids to define fishery needs on the Stanislaus River and help plan, select, and evaluate restoration actions.
- Evaluate the general Habitat Suitability Index models available for juvenile salmonids as to how well they represent the site-specific habitat conditions and populations of the lower Stanislaus River.
- Evaluate what factors may limit growth and survival, and downstream movements of juvenile anadromous salmonids, particularly what factors affect young salmon from reaching smolt size sufficiently early to allow successful migration through the Bay-Delta estuary before it warms and becomes intolerable for successful migration to the ocean.
  - Do juvenile Chinook emigrate on specific cues such as water temperature or river flow?
- Evaluate the extent of over-summering juvenile Chinook salmon and the potential contribution of this life history type based on on-going distribution and abundance surveys.
  - Is there a significant reduction in salmonid densities over the summer and if so what factors are related to that reduction?
  - Are there any differences in abundance between years and if so what factors might contribute to these differences?
- Determine life history types that contribute to anadromous salmon and steelhead escapement to the river based on distribution and abundance survey data.
- Evaluate the adequacy of lower river habitat for growth and survival of juvenile anadromous salmonids, especially fry and fingerling Chinook salmon.

- Relate the findings of the study to those of other studies documented in the scientific literature.

## Sampling Sites

The river from one mile below Goodwin Dam downstream to the vicinity of Oakdale was divided into eight reaches (Figure 1). Two to four sites were surveyed per reach for a total of twenty-two sites covering a range of habitat types within each reach. Access to the river was a consideration in site selection. The eight sample reaches were Goodwin Dam (RM 57.5), Two-Mile Bar (RM 56.6), Knight's Ferry (RM 54.5), Lovers Leap (RM 52.2), Honolulu Bar (RM 49.6), Orange Blossom (RM 46.9), Oakdale Recreation Area (RM 40), and McHenry Park (RM 28.5). Habitat types surveyed included low velocity (little or no current) and moving water, and in some cases experimental areas where gravel had been introduced to enhance spawning habitat. Whenever possible, slackwater pool margins were selected for the low velocity sites. In instances when no pool habitat was available, glide habitat margins were selected to represent slow-water habitat in a reach. Riffle or higher velocity glide habitats were selected to represent fast-water habitat. Areas near the downstream end of high gradient riffles or narrow reaches of glide habitat where velocities are higher relative to other glide habitat area were selected as fast-water habitat. Experimental sites were generally riffle habitat, but often had a combination of fast and slow water habitat. Experimental sites were not added to the survey design until week sixteen when it became obvious that these areas had unique habitat and unusually high use by juvenile salmonids. A more detailed description of the sampling sites is provided in Table 1. GPS coordinates are shown in Table 2.

Table 1. Survey reaches and sampling sites for snorkel surveys of the Stanislaus River in 2000 and 2001.

| Site | Slow | Fast | Experimental | Side Channel |
|---|---|---|---|---|
| **Goodwin Dam (RM 57.5)** | | | | |
| Length (m) | 63 | 42 | | |
| Average width (m) | 41.2 | 18.6 | | |
| Average depth (m) | 5.2 | 0.85 | | |
| Habitat type | Pool[1] | Riffle | | |
| **Two-Mile Bar** (RM 56.6) | **Slow** | **Fast** | | |
| Length (m) | 66 | 65 | | |
| Average width (m) | 36 | 24.3 | | |
| Average Depth (m) | 1.6 | 1.2 | | |
| Habitat type | Pool | Fast glide/riffle | | |
| **Knights Ferry** (RM 54.5) | **Slow** | **Fast** | **Experimental** | |
| Length (m) | 62 | 55 | 70 | |
| Average width (m) | 30.1 | 24.5 | 40.1 | |
| Average Depth (m) | 1.8 | 1.5 | 0.6 | |
| Habitat type | Slow glide/pool | Fast glide | Tailout/riffle | |

[1] Classification per DFG 1998.

| | | | | | |
|---|---|---|---|---|---|
| **Lovers Leap** (RM 52.2) | **Slow** | **Fast** | **Experimental** | | |
| Length (m) | 70 | 84 | 98 | | |
| Average width (m) | 24.6 | 19.6 | 39.1 | | |
| Average Depth (m) | 1.4 | 1.6 | 0.7 | | |
| Habitat type | Slow glide/lat. Scour | Fast glide/lat. scour | Mid-glide gravel bar | | |
| **Honolulu Bar** (RM 49.6) | **Slow** | **Fast** | | **Mid** | **Right** |
| Length (m) | 72 | 68 | | 45 | 45 |
| Average width (m) | 28.2 | 21.7 | | 20 | 7 |
| Average Depth (m) | 0.9 | 0.6 | | 0.55 | 0.5 |
| Habitat type | Slow glide | Fast glide/riffle tailout | | slow glide | fast glide |
| **Orange Blossom** (RM 46.9) | **Slow** | **Fast** | **Experimental** | | |
| Length (m) | 46 | 49 | 43 | | |
| Average width (m) | 31.2 | 26.8 | 26.4 | | |
| Average Depth (m) | 1.1 | 0.8 | 0.5 | | |
| Habitat type | Slow glide | Fast glide | Tailout/riffle/lat. scour | | |
| **Oakdale** (RM 40.0) | **Slow** | **Fast** | | **Side channel** | |
| Length (m) | 57 | 74 | | 50 | |
| Average width (m) | 23.9 | 24.5 | | 6 | |
| Average Depth (m) | 1.4 | 0.95 | | 0.43 | |
| Habitat type | Slow glide/lat. Scour | Fast glide | | fast glide/riffle | |
| **McHenry Park** (RM 28.5) | **Slow** | **Fast** | | | |
| Length (m) | 80 | 55 | | | |
| Average width (m) | 26 | 29 | | | |
| Average Depth (m) | >2 | 1.88 | | | |
| Habitat type | Slow glide/pool | Fast glide | | | |

Table 2. Midpoint coordinates for 2000/2001 Stanislaus River snorkel survey sites.

| Site Name | Latitude | Longitude |
|---|---|---|
| Goodwin Slow | N37.85755 | W120.63558 |
| Goodwin Fast | N37.85880 | W120.63547 |
| 2-Mile Bar Fast | N37.84334 | W120.64355 |
| 2-Mile Bar Slow | N37.84504 | W120.64341 |
| Knights Ferry Exp | N37.81885 | W120.66731 |
| Knights Ferry Slow | N37.81851 | W120.66632 |
| Knights Ferry Fast | N37.81817 | W120.66537 |
| Lovers leap Exp. | N37.80912 | W120.68100 |

| | | |
|---|---|---|
| Lovers Leap Slow | N37.80880 | W120.69317 |
| Lovers Leap Fast | N37.80840 | W120.69219 |
| Honolulu Bar | N37.80027 | W120.72658 |
| Orange Blossom Exp. | N37.78807 | W120.76250 |
| Orange Blossom Slow | N37.78947 | W120.76343 |
| Orange Blossom Fast | N37.78873 | W120.76296 |
| 0akdale Slow | N37.77080 | W120.87089 |
| Oakdale Fast | N37.77091 | W120.87019 |

## Methods

Sites within each reach were marked with red survey flags set at the upper and lowermost boundaries of each sample site. Additionally, orange colored rocks were placed in the divers path 1.5 meters (m) from shore to help them identify site boundaries.

During the first two surveys, sampling at each survey site consisted of two divers swimming upstream along the stream margin on opposite banks. Divers were positioned so that the maximum lateral area could be observed (~1.5 m from the river margin depending on visibility – Figure 2). In addition to the two upstream margin transects, a mid-stream transect was also surveyed. Initially the mid-stream area was surveyed laterally by stretching a rope across the river that allowed the diver to cross the river and record mid-stream fish use. This method was replaced after the second survey period because of the difficulty of observing fish. It was replaced by a mid-stream transect parallel to the two margin transects. Painted rocks were placed at 10-meter intervals along the approximate midpoint of the stream to guide the divers. After the upstream ascent in a margin transect, one diver descended the middle of the river using the painted rocks for orientation on the midline. This method proved much more effective in documenting midstream habitat use.

**Figure 2. Diver moving upstream along more of sampling site.**

Observations were recorded on dive slates. Variables recorded include fish species, age group (salmonid young, yearling, and adult), depth of observation, water column location, distance from bank, and any unique habitat conditions. Species were determined by divers trained in recognizing species with specialized training in distinguishing between young salmon and trout. Size was determined by training the divers to visually estimate the size of standard-length, painted, lead weights prior to each week's survey. Size of fish was recorded by groups, not individual fish. Depths were measured with a 3-ft PVC rod attached to the divers wrist.

For each sampling date and sampling site, indices of abundance were calculated for juvenile salmon and trout. The number of each species and life stage per 100 square meters surveyed for the entire site was calculated to provide an index of abundance for salmon and for trout. Because the area surveyed differed among the 24 sites, total observations were standardized to a 100 square-meter index.

Water temperature was recorded at each site at the start of each survey. Recordings were made at approximately the same time of day at each site within a reach for temporal consistency among sites.

Statistical analyses were conducted on the survey data to compare within and among reach water temperatures and fish observations. MS Excel statistical package was used for T-test comparison between means and Analysis of Variance among three or more treatments (sites or reaches). The log of the number of fish observed per 100 square-meter was used as the variable in tests of differences in mean number of fish observed. Generally, the patterns in fish density observed as described in this report were statistically significant.

## Results

### Stream Flows

The lower Stanislaus River discharge (flow) in the year 2000 study period from March 15 through December ranged from a high of 1580 cfs to a low of 350 cfs (Figure 3). Flows were maintained by reservoir releases at approximately 1500 from April 21 through June 11. These spring releases are generally referred to as the Vernalis Adaptive Management Program releases, which vary depending on the water year type. Flows were near 300 cfs for the remainder of the summer through the winter except for a short period of spill from October 17-25 when flows reached approximately 1100 cfs.

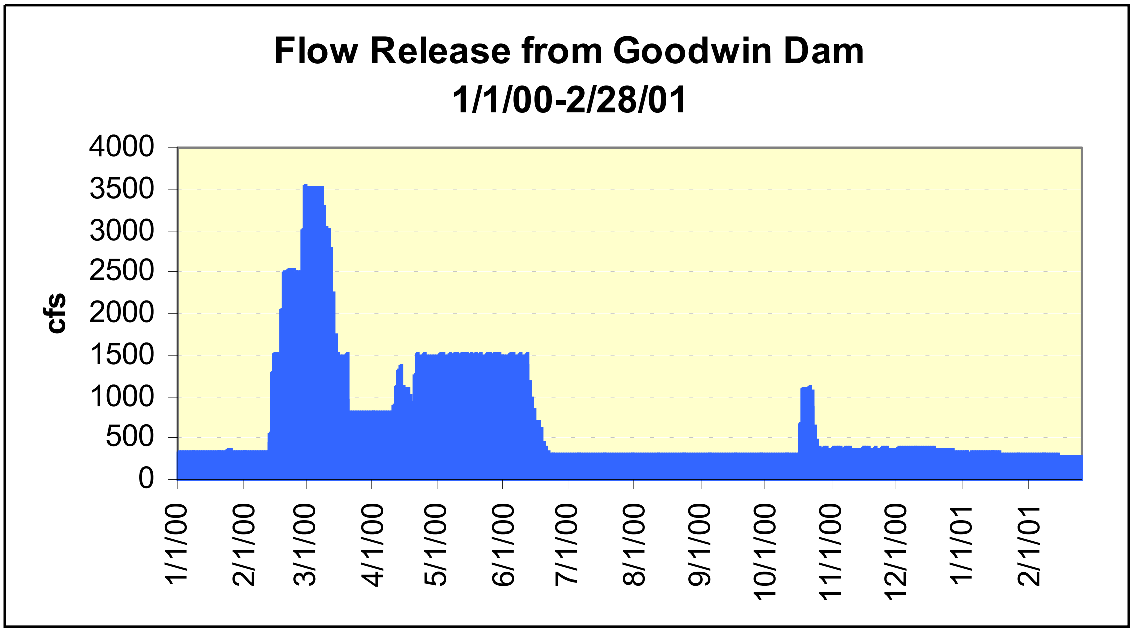



Figure 3. Daily Stanislaus River discharge from Goodwin Dam from 1/1/00 to 2/28/01. (Source: CDEC)

Flows were relatively low in 2001 with only one small peak of uncontrolled flow at the beginning of March (Figure 4). VAMP releases of 1200 cfs extended from April 20 to May 19. Summer storage releases varied from 400-800 cfs and reached the minimum release of 300 cfs in mid September.

### Stream Habitat

Differences in flow between year 2000 and 2001 resulted in significant changes in the amount of low-velocity, high-cover margin habitat, particularly in the fast-water sites of the upper four reaches of the river. During the higher flow periods, flooded vegetation was abundant at all sites. As flows receded in late spring of both years, the margin habitat receded as well. Flooded margin habitat under the 300-400 cfs base flows is only about 10% of that at 1500 cfs or higher based on visual observations. Side channels at the Honolulu Bar and Oakdale sites became disconnected from the main channel at flows less than 500 cfs. Stranding of young salmonids may have occurred in isolated pools of side channels when side channels became disconnected, however no surveys were made in the side channels after they became disconnected. The side channels remained watered after they were disconnected from the main channel via inter-gravel flow.

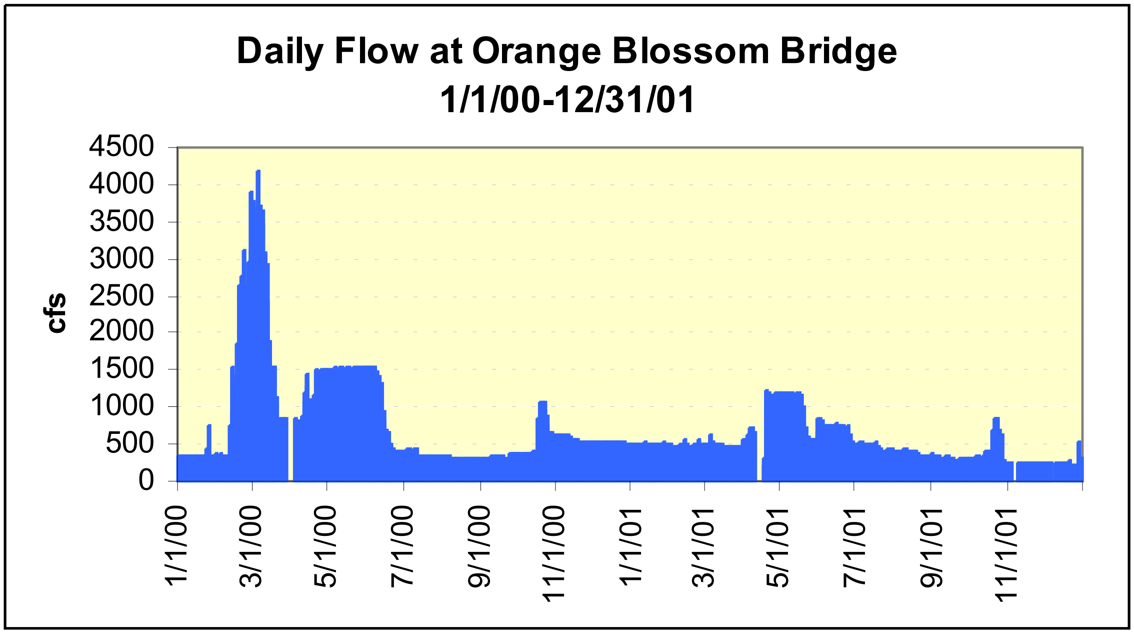



Figure 4. Daily Stanislaus River flow as measured at Orange Blossom Bridge from 1/1/00 to 12/31/01. Zero flow days were cause by gauge malfunction. (Source: CDEC)

## Water Temperature

Water temperature varied considerably with day and location during the study period between March 15, 2000 and December 2001 (Figure 5). Water temperatures reached a minimum of 8 to 10 °C during January, but warmed to near 15 °C by early April at the three lowermost stations. Water temperatures dropped about 2°C at the lower river stations at the onset of VAMP New Melones storage releases in mid April 2000 and 2001.

Water temperatures increased sharply as VAMP flow releases ceased declined and air temperatures peaked into early summer reaching 19°C at Oakdale and 13-14°C at Goodwin in both years. Water temperatures remained below 16°C through the study period at the upper reaches including Goodwin, Two-Mile bar, Knights Ferry, and Lovers Leap. Temperatures in excess of 16°C were recorded during the summer in the lower reaches including Honolulu-Bar, Orange Blossom Bridge and Oakdale.

Water temperatures began to decline in September and fell to 10-12 °C in all reaches by mid November.

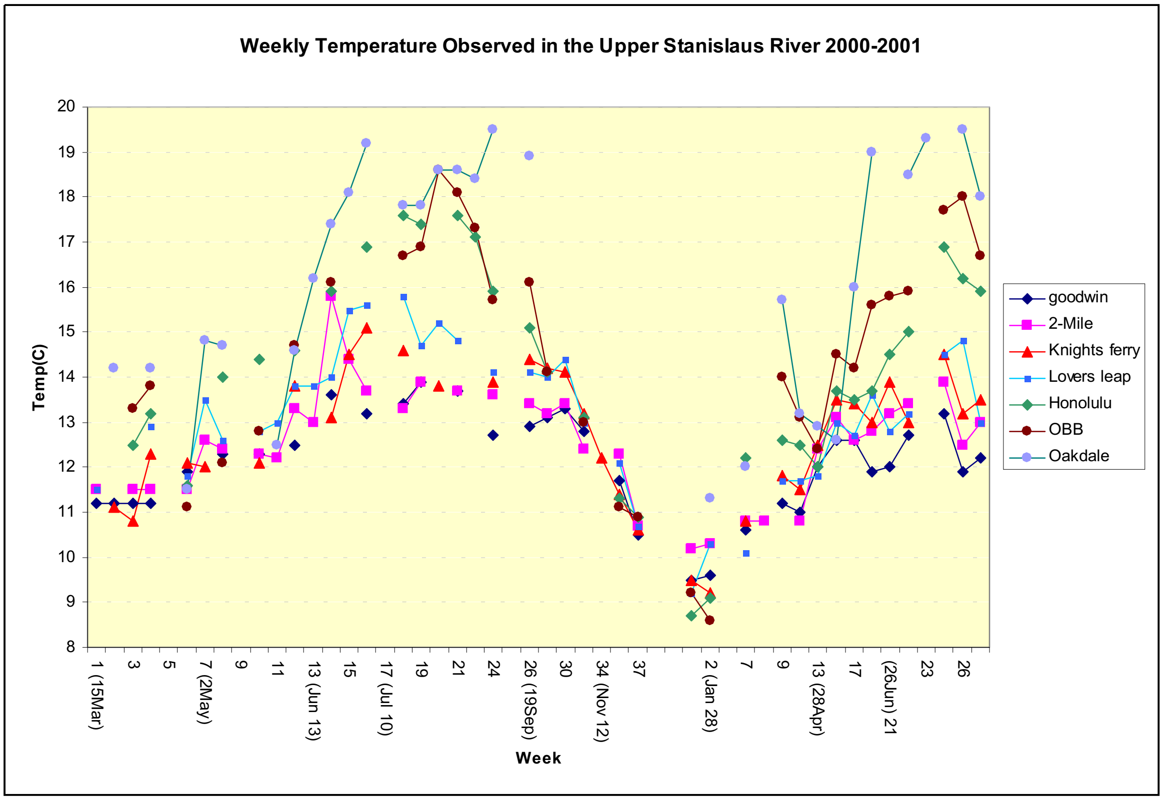



Figure 5. Water temperature measured during snorkel surveys from March 2000 to August 2001.

## Chinook Salmon Distribution

Year 2000 (Figure 6)

Young Chinook salmon were observed from the beginning of the surveys (March 26) through the end (December 18) in the Year 2000 survey (Figure 6). Peak abundance occurred during the first eight weeks of the survey (early March to early May) when densities reached 20 to 40 per 100m$^2$ in the middle and lower reaches. Most of the young salmon were fingerling pre-smolts in the 50-80 mm size range. Young salmon were relatively abundant at all sites with the exception of Goodwin where densities never exceeded 3/100m$^2$ after week 1.

Chinook densities declined after week 8 (May 7) with few observed after week 19 (July 24). From week 16 to 24 (July 3-Sept 5) Chinook were most abundant between Two Mile Bar and Lovers Leap. Most were 80-120 mm in size. Temperatures below Lovers Leap were unfavorable (>16$^o$C). From week 27 to week 35 (Sept 27-Nov 19) Chinook density was very low throughout the study area (<1/100m$^2$). Remaining Chinook observed were singles or doubles and were over 120mm in length. All were found in relatively high velocity habitat adjacent to deep water. None were observed after mid November.

Newly hatched fry (30-40 mm) were observed during the Week 37 (December 18). Fry densities were highest in Lovers Leap and at Orange Blossom Bridge, and lowest at Goodwin and Two-Mile Bar at the upper reaches of the river.

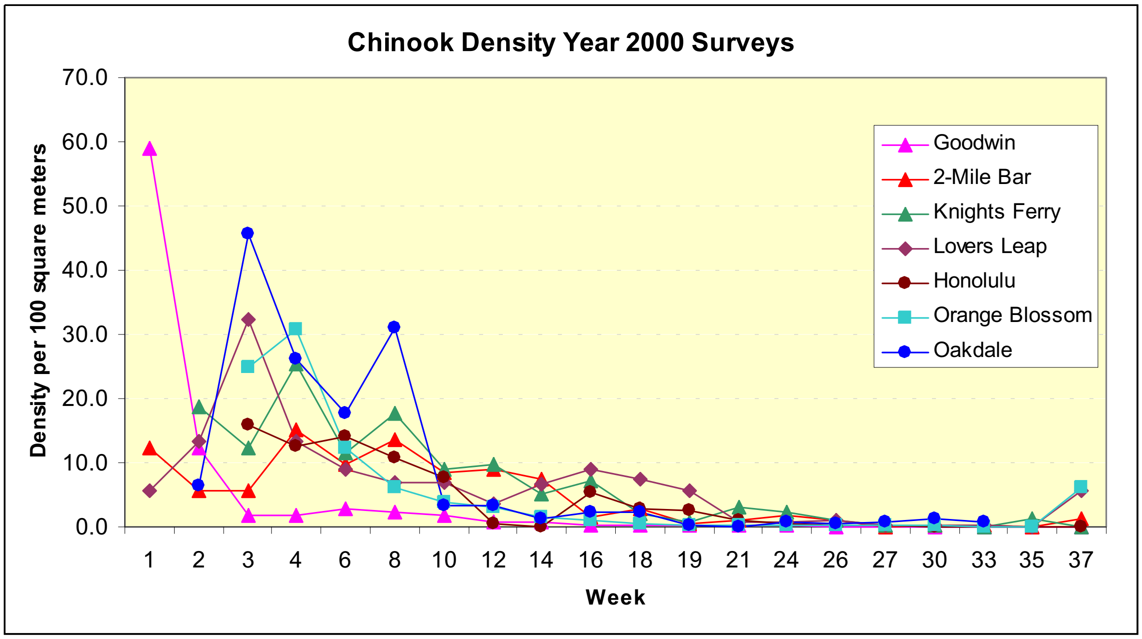



Figure 6. Average density of young Chinook salmon at seven sampling sites in year 2000 survey. (Week 1 began on March 15.)

<u>Year 2001 (Figure 7)</u>
Surveys began in late January in year 2001. Fry were least abundant in the upper reaches especially at Goodwin where densities were the lowest (Figure 7). Density declined gradually after week 5 (February 25) and then dropped more sharply between week 11 (April 14-21) and 15 (May 12-19). Density was very low by week 17 (May 25). Generally density was substantially higher in most reaches in the spring of 2001 than 2000.

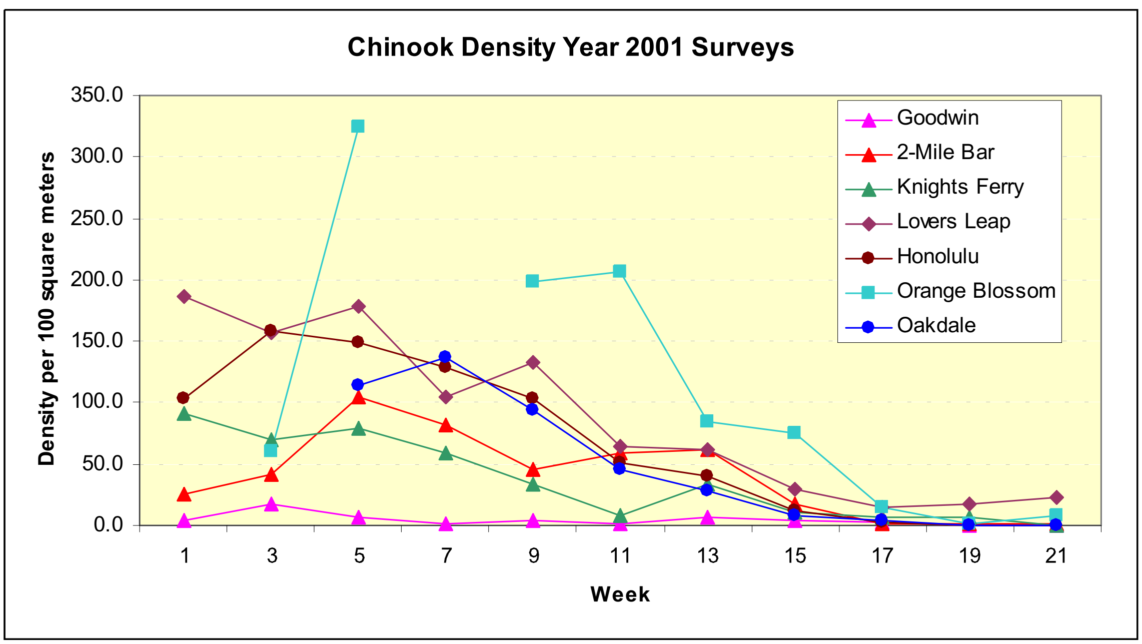



Figure 7. Average density of young Chinook salmon at seven sampling sites in year 2001 survey. (Week 1 began on January 22.)

## Trout Young (Age 0)

Year 2000 (Figure 8)

Young trout began to appear in mid April (week 4) from Goodwin Dam downstream to Lovers Leap (Figure 8). They did not appear in higher numbers in downstream reaches below Lovers Leap until late June (week 14). They were most abundant through the year at Goodwin and Two-Mile Bar at the upper end of the survey area. They were also relatively abundant at Knights Ferry, Lovers Leap, and Orange Blossom late in the year at experimental sites within these reaches (experimental sites are discussed later). By week 37 (December) few were observed.

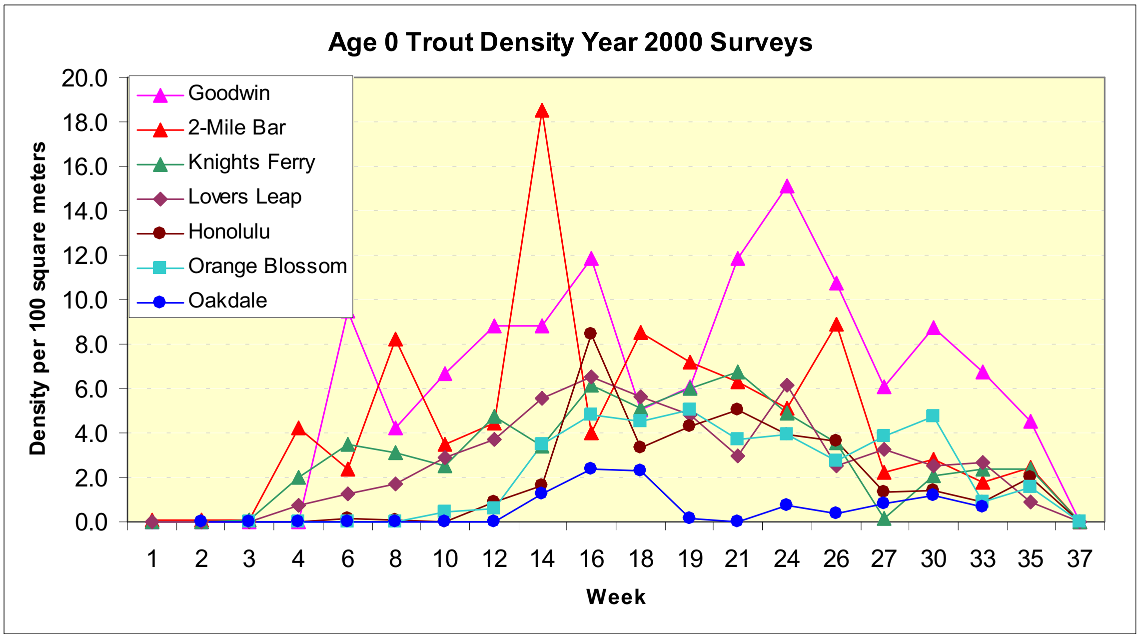



Figure 8. Average density of young trout at seven sampling sites in year 2000 survey. (Week 1 began on March 15.)

Year 2001 (Figure 9)

In year 2001 young trout began to appear in April (survey week 4) in the upper river reaches as in year 2000 (Figure 9). They began appearing in higher densities in the lower reaches in May. Highest densities occurred at upper river reaches and at experimental sites in the lower river reaches (Knights Ferry, Lovers Leap, and Orange Blossom).

## Trout Yearlings (Age 1+)

Years 2000-2001 (Figures 10 and 11)

Yearling trout were observed through most of the survey periods, and were most abundant in the upper reach between Goodwin Dam and Two-Mile Bar (Figures 10 and 11). They became more common in the lower reach in late spring, particularly at experimental sites in the lower river reaches (Knights Ferry, Lovers Leap, and Orange Blossom).

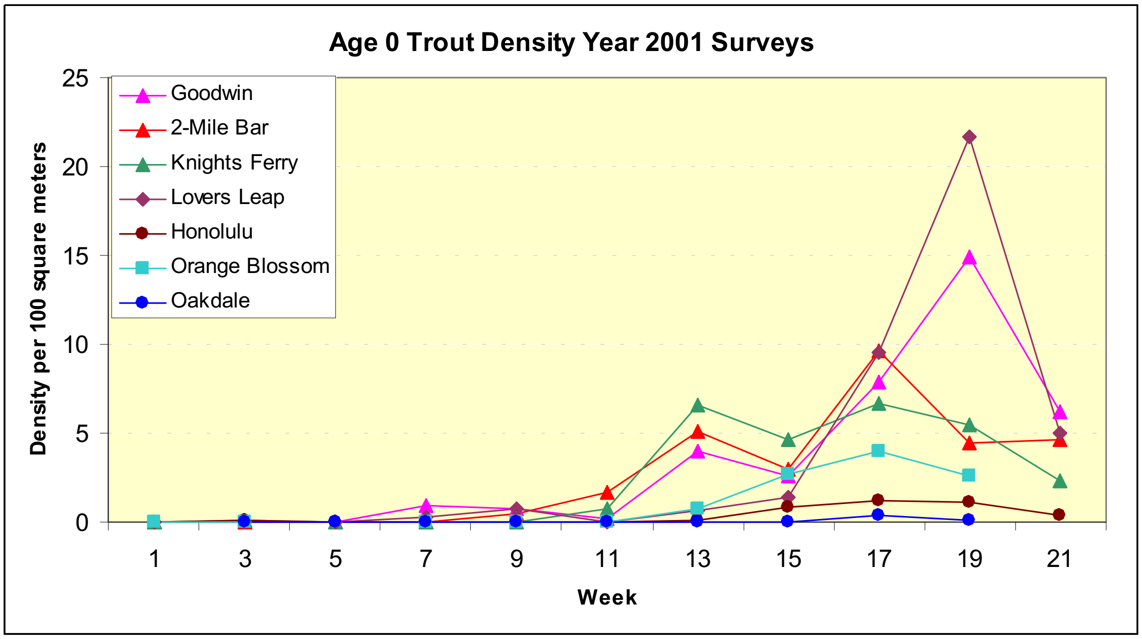



Figure 9. Average density of young trout at seven sampling sites in year 2001 survey. (Week 1 began on January 22.)

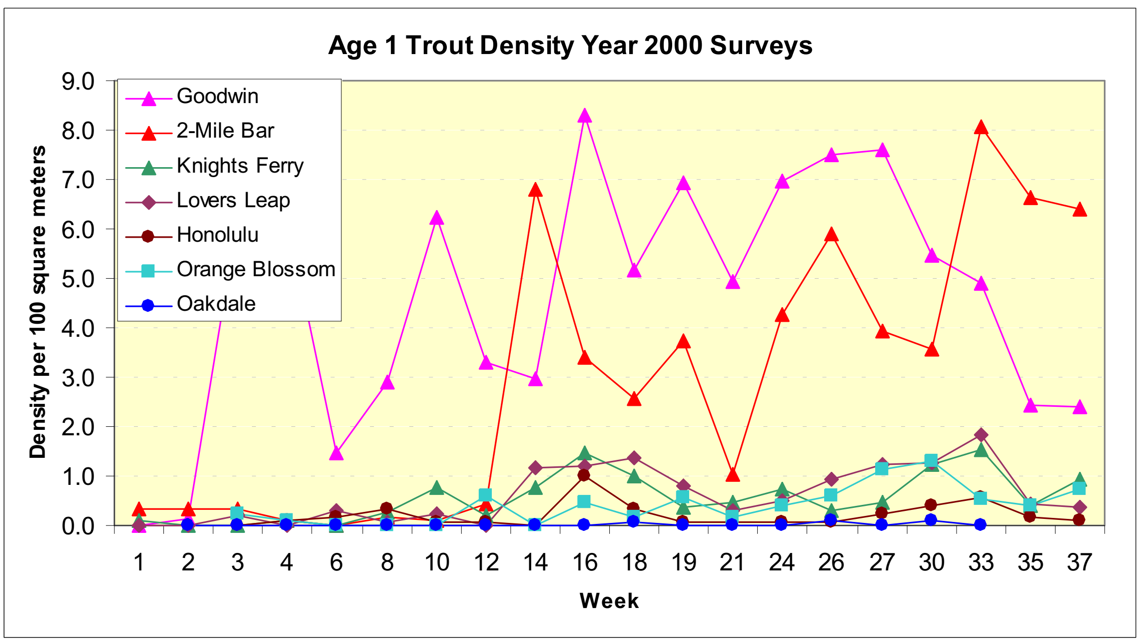



Figure 10. Average density of 1+ trout at seven sampling sites in year 2000 survey. (Week 1 began on March 15.)

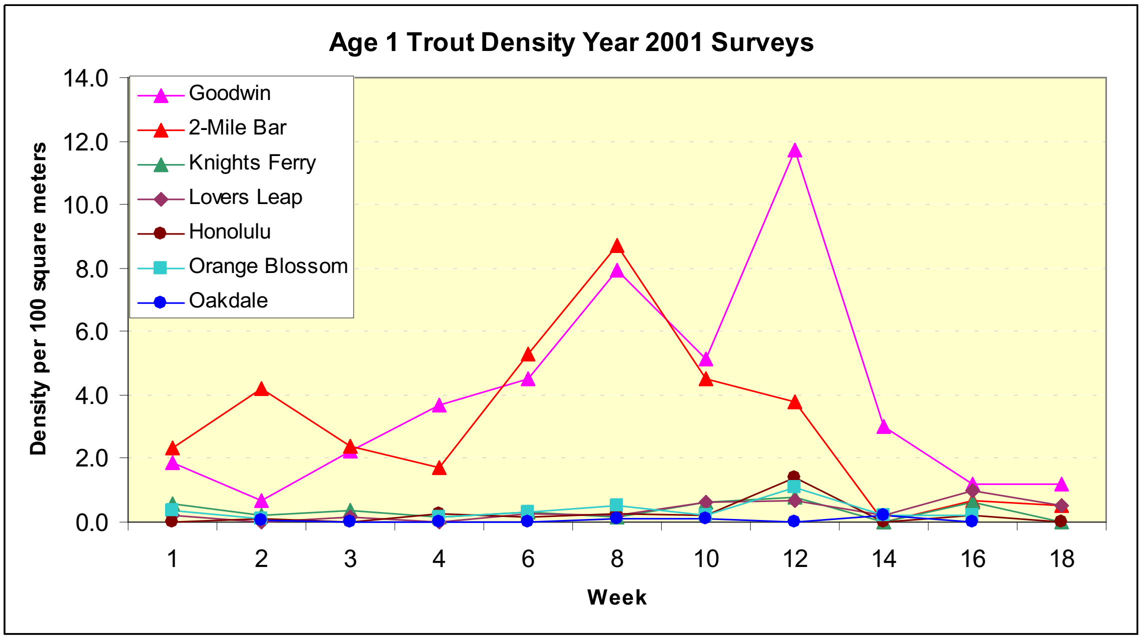



Figure 11. Average density of yearling trout at seven sampling sites in year 2001 survey. (Week 1 began on January 22.)

## Observations of Adult Chinook

On 6 June 2000, three adult Chinook were observed in a deep pool during snorkel surveys at the Knights Ferry Bridge. These fish were in poor condition and appeared to have already spawned. An adult female was captured by hand and photographed. A brief examination confirmed that she had spawned (badly abraded lower caudal fin and absence of eggs). The condition of the fish at that time of year strongly suggests that it was a winter-run salmon, but it could not be confirmed without genetic testing.

To better document the presence of adult Chinook in the river at that time, bi-monthly exploratory dives were conducted from Goodwin Dam to Knights Ferry.

Adult Chinook were observed on six dates from Goodwin Dam down to Orange Blossom Bridge:

- **20 June 2000 -** Seven adult Chinook salmon (approximately 10 pounds) were observed from Two-Mile Bar to one mile above Knights Ferry. Fish were brightly colored (pre-spawn) and all were observed in deep turbulent pools.

- **12 July 2000 -** Two adult Chinook salmon were observed between Goodwin Dam and Lovers Leap: one female approximately 10 lbs and one male approximately 25 lbs. They were found in a deep turbulent pool below an approximately 7-ft fall.

- **13 July 2000 -** Seven adult Chinook salmon approximately 8-10 lbs were observed in a slow deep pool one mile above the Orange Blossom Bridge. All were very bright (silvery) suggesting that they had recently migrated into the river.

- **21 July 2000 -** Seven adult Chinook salmon were observed between Goodwin Dam and Two-Mile Bar. Fish were again bright and weighed approximately 12-15 lbs. All were observed in the turbulent head of a deep pool.

- **3 August 2000 -** Two adult Chinook salmon were observed on a shallow gravel bar at Lovers Leap. No evidence of recent spawning activity was observed in the area.

- **11 August 2000 -** Nine adult Chinook salmon were observed from Goodwin Dam to Knights Ferry. Fish ranged in size from 10-30 lbs and were in turbulent pool and slow water pool habitats. To verify these observations, DFG deployed gill nets overnight in the Button Brush recreation area. Twenty-two adult Chinook salmon were captured and of those, three were adipose clipped fish. The ad-clipped fish were later determined to be strays from the Feather River Hatchery. (Note that only a small percentage of Feather River Hatchery salmon are code-wire tagged and adipose fin clipped.)

### Observations of Adult Rainbow Trout

Adult rainbow trout including some that appeared to be steelhead were observed sporadically in the river. Some large trout in excess of 500 mm in length that appeared to be resident trout were observed as well. Age 2+ trout in the 300 to 600 mm length range were common but difficult to observe and accurately count because they were wary and generally remained long distances from divers.

## Discussion and Conclusions

### Distribution of Juvenile Salmon in Lower Stanislaus River

Fry salmon were abundant throughout the survey area by January. Density of fry salmon was lowest in the upper sites below Goodwin Dam. Exploratory dives in the reach between Goodwin Dam and Two-Mile Bar found the reach was made up of deep, slow pools and high gradient riffles with little spawning habitat. Pool tailouts within this reach were highly scoured and possessed mainly angular cobble substrate with diameters in excess of three inches (median axis). Although several redds were observed in these tailouts, the reach generally lacked spawning gravels. The favorable rearing conditions observed in this reach throughout the year make it a prime candidate for spawning habitat restoration. Maximizing the spawning potential within this reach for salmon and trout would allow for better utilization of the optimal rearing habitat of the upper reaches.

Abundance of juvenile salmon declined rapidly throughout the river during the periods of VAMP storage releases (April 16 to June 15 in 2000; and April 16 to May 15 in 2001). This decline is likely indicative of active emigration of fingerling and smolt salmon downstream into the lower river, the San Joaquin River, and the Bay-Delta. Small numbers of juvenile salmon were observed through the summer in the upper reaches where water temperatures did not exceed 16 $^{o}$C especially at experimental sites in the Lovers Leap and Knight's Ferry reaches.

### Distribution of Juvenile Trout in Lower Stanislaus River

Young trout began to emerge from the gravel at the upper river sites by April and were abundant from May through September. They were most abundant at Goodwin and Two-Mile Bar in the upper most section and least abundant at Oakdale, the lowermost site. Young trout reached the lower river sites by June where they remained common through the summer and fall except at Oakdale, the lower most reach where water temperature was the highest in the study area at 18-20$^{o}$C.

By December few young trout were observed as water temperature fell to 10$^{o}$C. We speculate that a combination of (1) emigration from the river after the first fall rains in November, (2) reduced visibility, and (3) young trout seeking refuge under larger substrate were the reasons for the decline in young trout observed. Few were observed until the following April when water temperature rose above 10$^{o}$C. The disappearance of young salmonids into substrate cover at temperatures at or below 10$^{o}$C is well documented in the literature (e.g., Bjornn 1973; Rimmer et al. 1983). This is also the point when many juvenile salmonids emigrate from their natal rivers after over-summering (e.g., Rimmer et al. 1983).

Yearling and post-yearling trout were concentrated in the upper river in the Goodwin and Two-Mile Bar reaches for most of the 2000 and 2001 survey period. Small numbers were observed in lower reaches particularly within experimental sites (Knight's Ferry, Lovers Leap, and Orange Blossom). Water temperatures rarely exceeded 15 $^{o}$C in the upper river, whereas downstream temperatures were near or reached stressful levels of

18-20 °C during most of the summer. Yearling trout were slightly more abundant in 2001 than in 2000 in downstream reaches. Water temperatures in 2001 were slightly lower under higher flows than in 2000. Abundance at Goodwin and Two-Mile Bar appeared to increase over the summer, which may indicate a positive upstream movement of yearling trout into the cooler waters of the upper river below Goodwin Dam.

### Movement and Factors Related to Movement

A relatively high proportion of juvenile salmon likely emigrate from the Stanislaus River as fry during the winter of wet years. The relatively low densities of young salmon observed in 2000 as compared to 2001 was possibly due to high winter emigration during high flows in 2000; whereas, flows were lower through the winter of 2001. Another explanation for the higher densities of salmon in 2001 is that greater escapement of adult salmon occurred in the fall of 2000 than in 1999, which resulted in greater production of young in 2001.

In both 2000 and 2001 it appeared that large numbers of juvenile salmon migrated from the river during VAMP storage releases. As designed VAMP pulse flows in spring may trigger emigration of pre-smolt and smolt salmon from the river.

VAMP storage releases from mid April through mid May (2001) or mid June (2000) may also trigger downstream dispersal of age 0 trout into the lower reaches especially in years such as 2001 when the only pulse of flow for the year is the VAMP flow.

The VAMP flows may thus serve to not only aid dispersal and emigration, but to minimize competition between young salmon and trout by making room for the trout when the salmon leave the river as observed by Everest and Chapman (1972) in Idaho streams.

### Habitat Use by Juvenile Salmon and Trout in the Lower Stanislaus River

Soon after emergence in winter, fry salmon were observed concentrated in slow-water, margin habitats of the entire study reach. As they grew through the spring they were more abundant in faster water and were often observed sharing feeding lanes on current seams with young, yearling, and adult trout.

Throughout the spring and summer, velocity appeared to play a more important role in where salmonids were in a given habitat unit as they were often observed in higher velocity areas without vegetation and less often observed in low velocity, vegetated areas where they concentrated as fry. Likewise, under lower summer flow, juvenile salmonids sought out higher velocity water towards the head or tail of pools.

Both salmon and trout showed a strong preference for habitat of the experimental sites[2]. Reaches with experimental sites had more young salmon and trout, and much higher densities at experimental sites than non-experimental sites. The experimental sites were generally much shallower than other sites, as experimental sites generally consisted of areas where large amounts of gravels were introduced into reaches and sites within

[2] Detailed data presentations by experimental and non-experimental sites are shown in the appendix.

reaches that were otherwise deep water. These results are consistent with those of Baltz et al. (1987) who found depth important in macrohabitat choice of juvenile rainbow trout. At the non-experimental sites water depths are much greater because of channel incising, gravel mining, and lack of gravel recruitment. The gravel additions at the experiment sites add more than gravel, they fill the channel and provide proper depths and geomorphic conditions (per Lanka et al. 1987) as well as substrate for young salmonids. Moyle and Baltz (1985) found young trout preferred water depths of about 36 cm, while yearlings and adults preferred 63 and 82 cm, respectively. All of these depths are far more abundant at the experimental sites. Water column velocities and substrates are also more optimal for trout at the experimental sites. The fact that young salmon and trout, as well as yearling and older trout all preferred the experimental sites in the river is an indication that preferred habitat for all three groups is severely lacking in the lower Stanislaus River. Concentrations of all three groups in the limited experimental sites may be an indication of intense competition or even predation (by yearling and older trout on young trout and salmon). Under such circumstances the production of young salmon and trout is likely limited by the intense competition and predation as suggested by Hearn (1987). For Chinook salmon populations that are already depressed as in the case of the Stanislaus River population, such competition and predation could be a severe limitation to recovery (Link 2002).

Based on snorkel observations, fry salmon and trout often selected flooded vegetation in the river channel as it provided velocity refuge, overhead cover, and protection from predators (see photo below).

**Juvenile Chinook salmon hiding in vegetated cover in the Stanislaus River.**

The classic winter shift of trout and salmon from faster shallower water to slower deeper pool water (Bustard and Narver 1975) was not a dominant feature in this survey. Only at Two-Mile Bar did there appear to be a shift from the faster water to the slower pool water in the autumn. Even then the pattern was not significant (Appendix B).

The classic segregation of different size-age groups of trout and salmon (Baltz and Moyle 1984) was readily apparent. Young trout and salmon tended to use the slower sheltered waters while yearling and older trout used faster waters. Young salmon appeared to move downstream during the winter and spring and avoided the upper reaches where yearling and older trout densities were high.

Young salmon also used the river predominantly in late winter and spring, whereas, young trout were predominant in late spring, summer, and fall.

In general, the habitat use patterns observed appears complicated by the continued growth of individual fish and changes in habitat (e.g., flow and water temperature) through the seasons, as observed in many previous studies (Hearn 1987).

## Predatory Fish

Striped Bass were observed at Lovers Leap and further upstream at Knights Ferry from May through the end of June. Fish ranged from 5 –30 pounds and were observed in all habitats. Striped bass were observed chasing juvenile trout on two occasions. The upstream extent of striped bass is thought to be the three-foot-high falls in the Knights Ferry reach at the historic Knights Ferry Bridge. This barrier may be important in limiting striped bass predation on juvenile salmonids to the river above the falls.

American shad were observed on three occasions in June through July at Lovers Leap. Shad were in schools of 20 or more and in faster water. Although no predation was observed, it has been documented that shad prey upon juvenile salmonids (Red Bluff Diversion Dam predation studies, Terry Mills DFG personal communication).

Predation by striped bass and American shad may pose a threat to salmonids residing in and migrating from the Stanislaus River. Juveniles in the upper river where the water is less turbid may stand a higher chance of being preyed upon. The recently approved Portable Alaskan Weir Project near the mouth of the river may provide a unique opportunity to exclude both striped bass and American shad from migrating up the river.

## Literature Cited

Baltz, D., and P. Moyle. 1984. Segregation by species and size classes of rainbow trout and Sacramento suckers in three California streams. Env. Biol. of Fishes 10: 101-110.

Baltz, D., B. Vondracek, L. Brown, and P. Moyle. 1987. Influence of temperature on microhabitat choice by fishes in a California stream. Transactions of the American Fisheries Society 116: 12-20.

Bjornn, T. C. 1971. Trout and salmon movements in two Idaho streams as related to temperature, food, stream flow, cover, and population density. Transactions of the American Fisheries Society 100: 423-438.

Bustard, D., and D. Narver. 1975. Aspects of the winter ecology of juvenile coho salmon (*Oncorhynchus kisutch*) and steelhead trout (*Salmon gairdneri).* J. Fish. Res. Board Can. 32: 677-680.

DFG (California Department of Fish and Game). 1998. California Salmonid Stream Habitat Restoration Manual. Third Edition. Inland Fisheries Division. California Department of Fish and Game. Sacramento, CA. 495 pp.

Everest, F., and D. Chapman. 1972. Habitat selection and spatial interaction by juvenile chinook salmon and steelhead trout in two Idaho streams. J. Fish. Res. Board Can. 29: 91-100.

Hearn, W. E. 1987. Interspecific competition and habitat segregation among stream-dwelling trout and salmon: a review. Fisheries 12(5): 24-29.

Lanka, R. P., W. A. Hubert, and T. A. Wesche. 1987. Relations of geomorphology to stream habitat and trout standing stock in small Rocky Mountain streams. Transactions of the American Fisheries Society 116: 21-28.

Link, J. S. 2002. Ecological considerations in fisheries management: when does it matter? Fisheries 27(4): 10-17.

Moyle, P., and D. Baltz. 1985. Microhabitat use by an assemblage of California stream fishes: developing criteria for instream flow determinations. Transactions of the American Fisheries Society 114: 695-704.

Rimmer, D., U. Paim, and R. Saunders. 1983. Autumnal habitat shift of juvenile Atlantic salmon (*Salmo salar*) in a small river. Can. J. Fish. Aquat. Sci. 40: 671-680.

Williams, J. G. 2001. Chinook Salmon in the Lower American River, California's Largest Urban Stream. *In:* Contributions to the Biology of Central Valley Salmonids. Fish Bulletin 179: Volume Two, Pages 1-38.

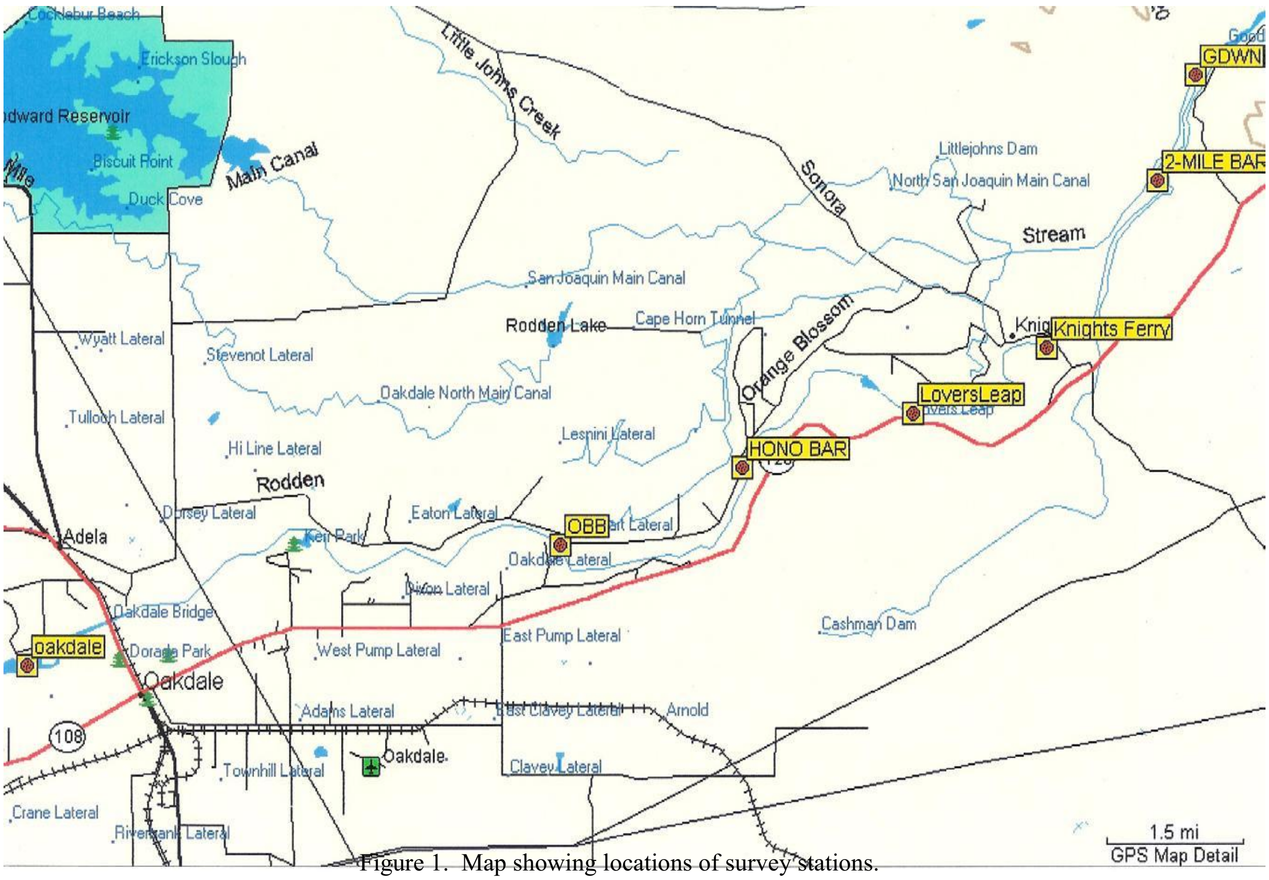
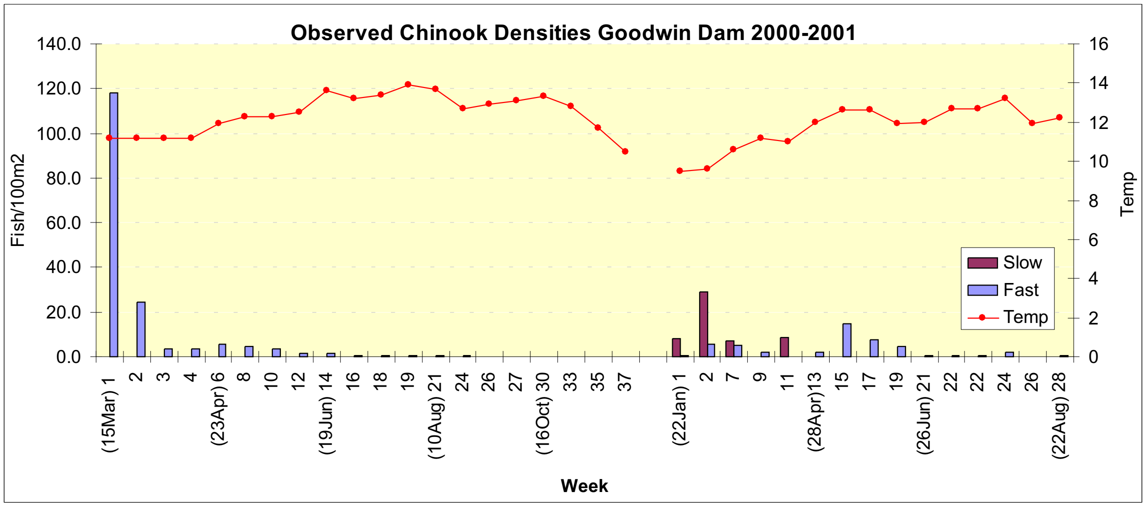
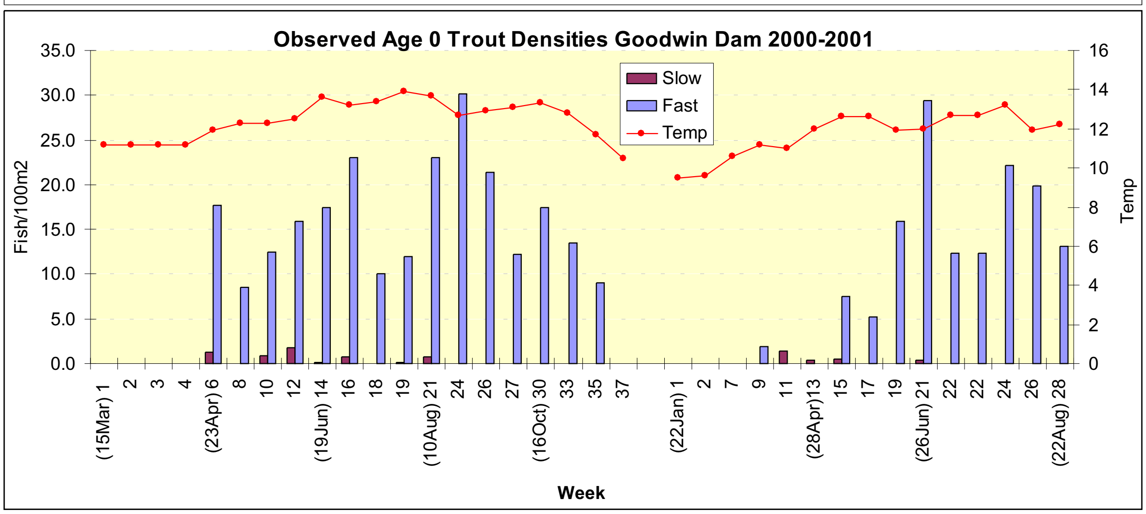


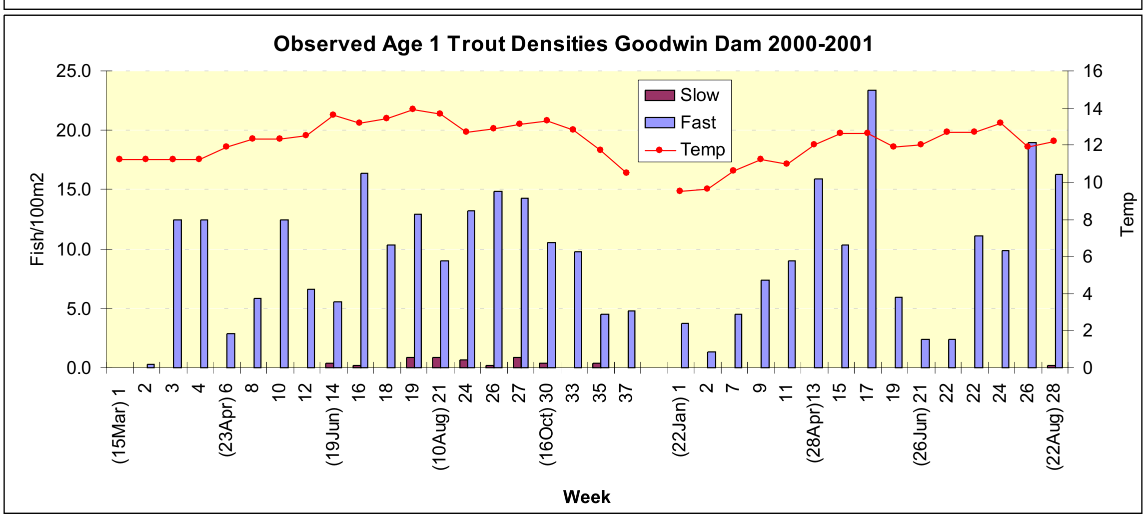
Figure 1. Map showing locations of survey stations.

Figure 1. Locations of Stanislaus River Snorkel survey reaches.

# Appendix A – Goodwin Reach



### Juvenile Salmon

In the Goodwin reach, with the exception of weeks 1 and 2 of year 2000 and week 2 of year 2001, Chinook densities were low (<20/100m$^2$) throughout the survey period in both the fast and slow sites. Density was highest at the fast-water site after February, whereas it was higher at slow water sites in January and February 2001. Only fry were observed at the slow site and most often on the extreme margin in less than 3 inches of water. No young salmon were observed at either habitat site after week 24 in year 2000.

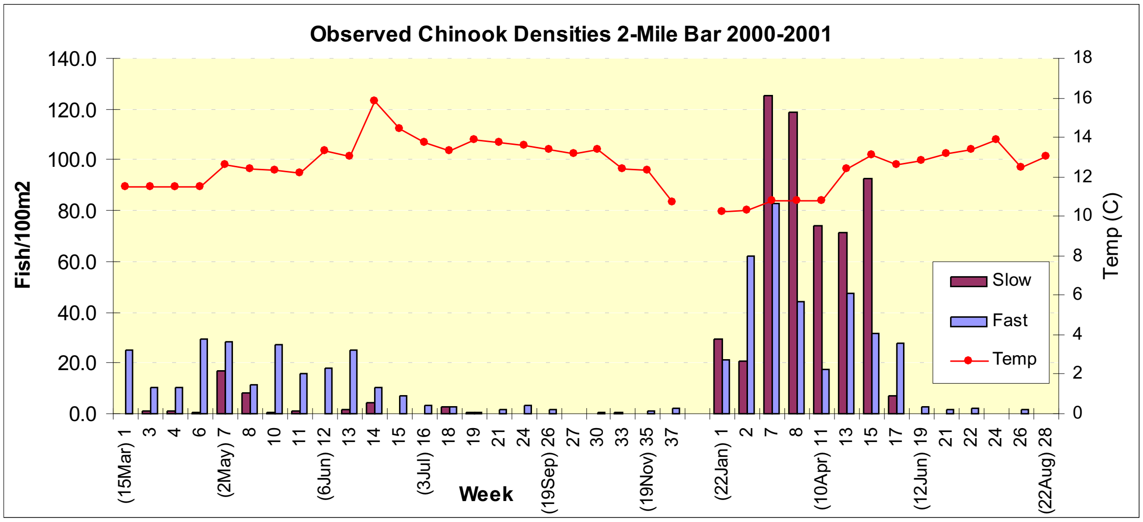
### Age 0 Trout

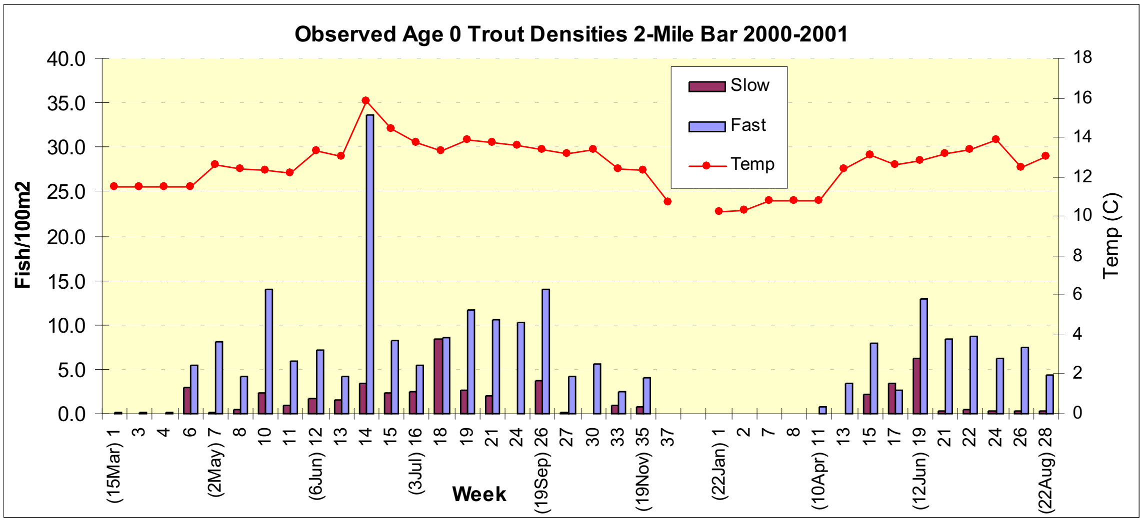
Age 0 trout first were observed at Goodwin in late April 2000 and late March 2001. They remained abundant through the spring and summer of both years, and through the fall of 2001. Nearly all young trout observed were in the fast water site.

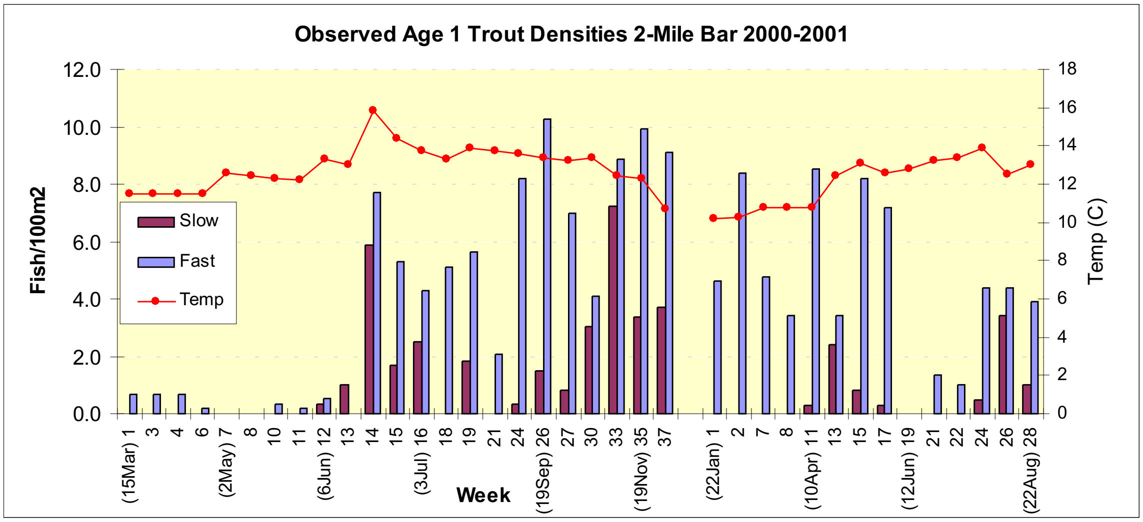
### Age 1 Trout

Age 1 trout were relatively abundant year-round at Goodwin. Nearly all were observed in the fast water site.

# Appendix B - Two-Mile Bar Reach



### Juvenile Chinook Salmon

Chinook salmon were observed throughout the survey period. Peak densities in year 2000 occurred from week 6 through week 13 (10-30/100$m^2$) after which they steadily declined through week 35. Most were observed in the fast water section. Juvenile salmon were far more abundant in 2001. One explanation is the high winter flows in 2000 may have moved many newly emerged fry downstream of the study reach; whereas the low flows of 2001 retained more fry. Fry from fall 2000 spawners began to appear in week 37 of 2000. In 2001 from January through mid May higher densities occurred in slow water as fry predominated. Most of the young salmon left the reach during a month of VAMP flows from mid April to mid May.

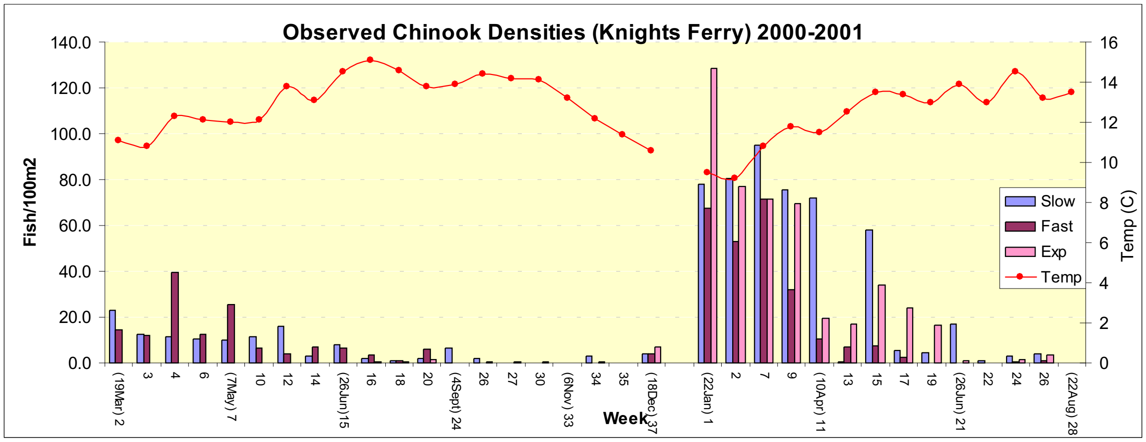
### Age 0 Trout

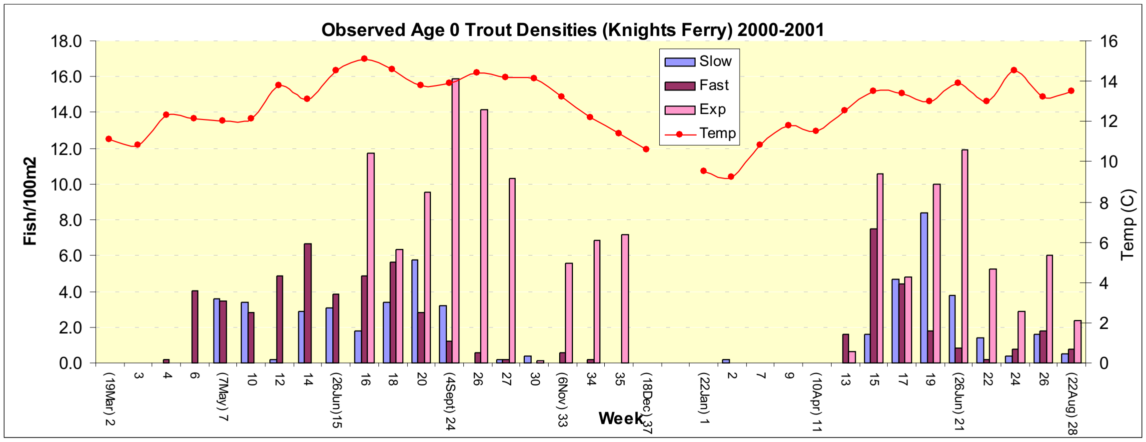
Age 0 trout first appeared in abundance in April 2000 and 2001. They were observed through the remainder of each year with the majority observed at the fast water site.

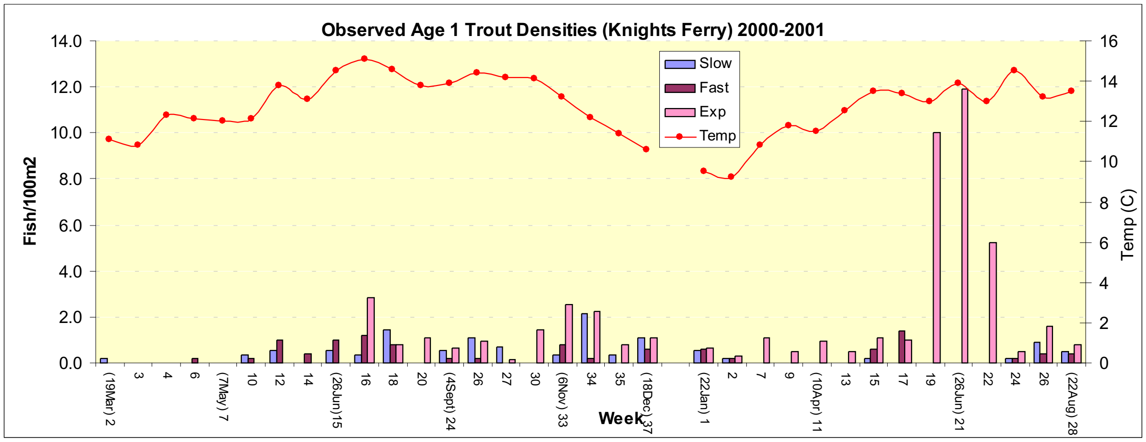
### Age 1 Trout

Age 1 trout were relatively abundant year-round at Two-Mile Bar. The majority was observed at the fast water site.

## Appendix C – Knight’s Ferry Reach



### Juvenile Chinook Salmon

Three sites were surveyed in the Knights Ferry reach: slow-water, fast-water, and experimental. The slow-water site was a glide where velocities were slightly higher than the true slackwater sites found upstream in Goodwin and Two-Mile Bar. The experimental site was added in week 16 after observations made during exploratory surveys at a similar site in the Lovers Leap reach indicated concentrations of juvenile salmonids at gravel introduction sites.

As at the upper two sites previously discussed, the density of young salmon observed was much higher in 2001 than 2000. Young salmon were abundant in all three habitat types until mid April after which most were captured in the experimental and fast water sections.

The salmon observed in week 37 of 2000 included newly hatched fry as well as yearlings of the 1999-2000 cohort that remained as a small group of 12-15 fish that were observed periodically at the head of a mid channel pool that was approximately 11 feet deep. The yearling salmon were all in excess of 120 mm and were fully smolted when last observed.

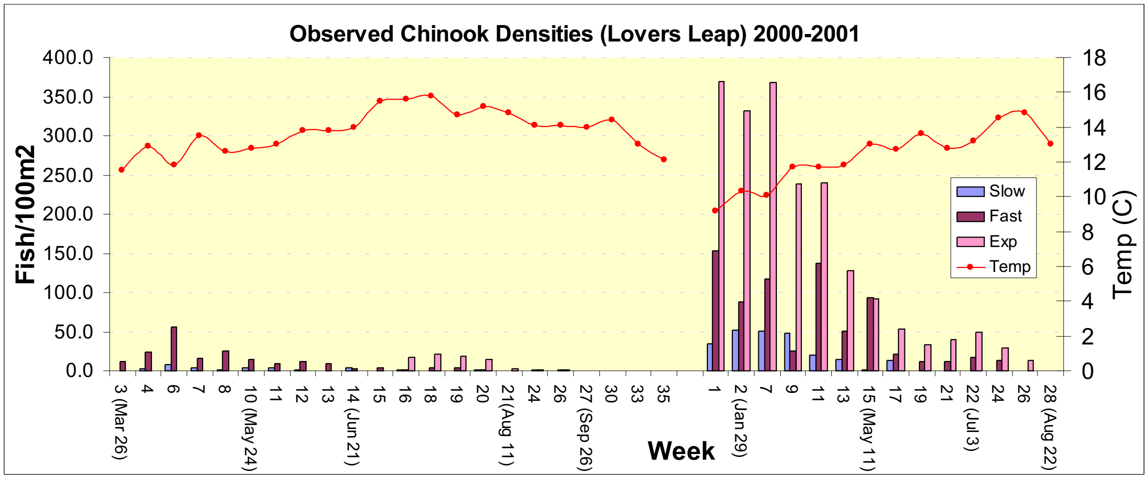
### Age 0 Trout

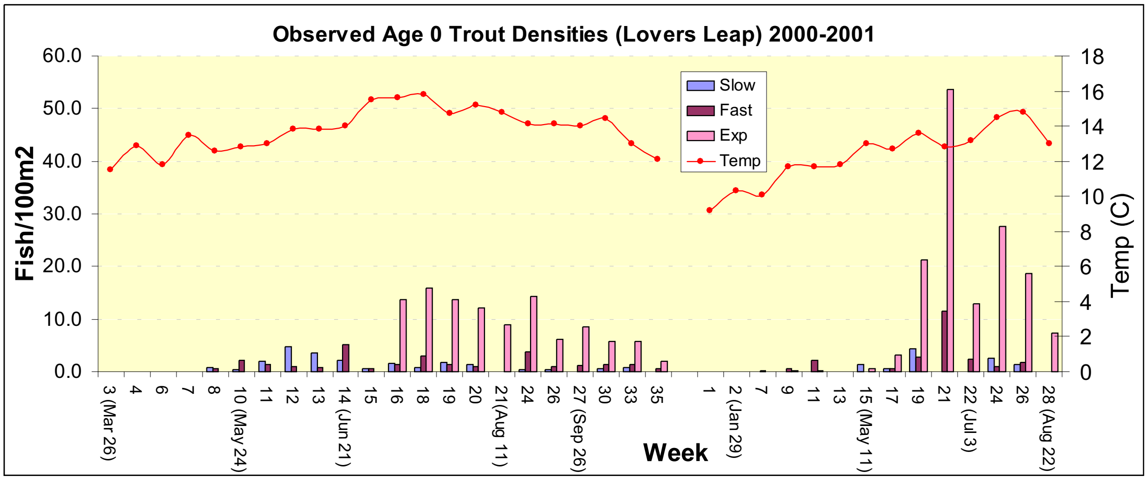
As at the upstream stations, age 0 trout first appear in April of 2000 and 2001. They were most abundant at the experimental station especially during the summer and fall. Note that surveys did not commence at the experimental station until week 16 of 2000.

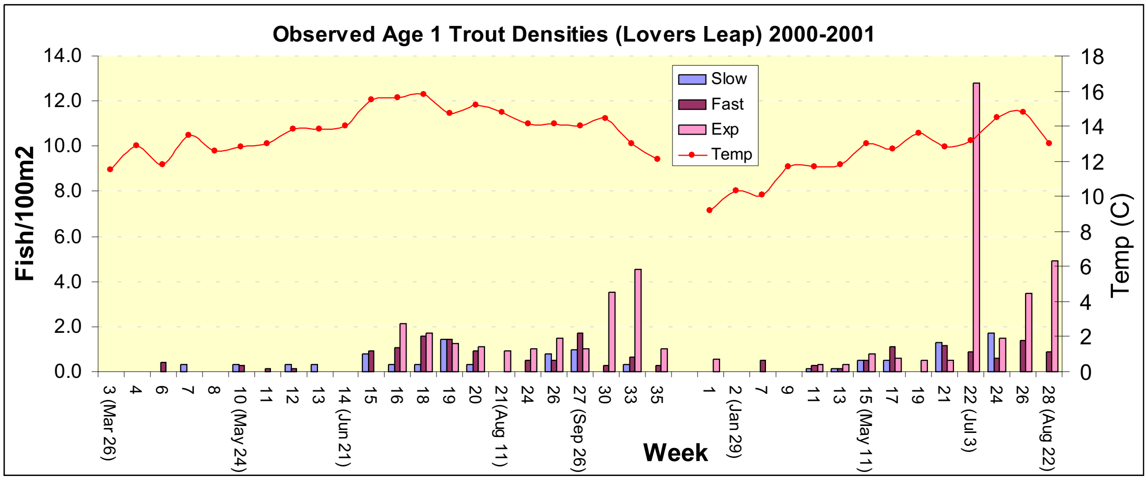
### Age 1 Trout

Age 1 trout were captured in low numbers through most of the study period at Knight's Ferry. As for young, yearling densities were higher at the experimental station.

## Appendix D – Lovers Leap Reach



## Juvenile Chinook Salmon

Three sites were surveyed in the Lovers Leap reach: slow-water, fast-water, and experimental. The experimental site was added in week 16 after observations made during exploratory surveys in the reach indicated concentrations of juvenile salmonids at gravel introduction sites. The number of young salmon observed in 2000 declined gradually through week 14. Salmon numbers rapidly declined in both the slow and fast habitats, but particularly in the slow water habitat. At this time snorkel surveys were extended over much of the reach to determine if there was an unseen shift in distribution to habitats that were being overlooked. Nothing unusual was observed except at a site approximately 0.5 miles upstream where at a gravel introduction site where salmon densities similar to peak densities observed earlier in the year at the fast and slow sites were noted. Thereafter this new site was also included in the survey, as were similar experimental sites at Knight's Landing and Orange Blossom Bridge. Salmon densities in excess of 15 per 100m2 were observed at this new site through week 20, after which density rapidly declined through week 30.

As at the upper three sites previously discussed, the density of young salmon observed was again much higher in 2001 than 2000. Young salmon were most abundant in the experimental habitat. Densities in the experimental site were also about double those in the slow water site and more than 4 times the observed density from the fast water site.

No salmon fry were observed in week 37 as at the upper three stations.

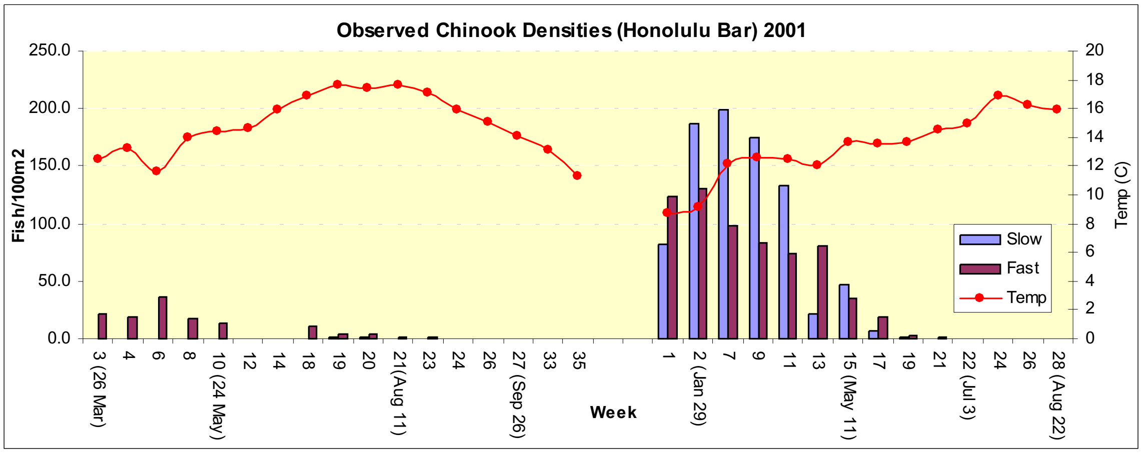
## Age 0 Trout

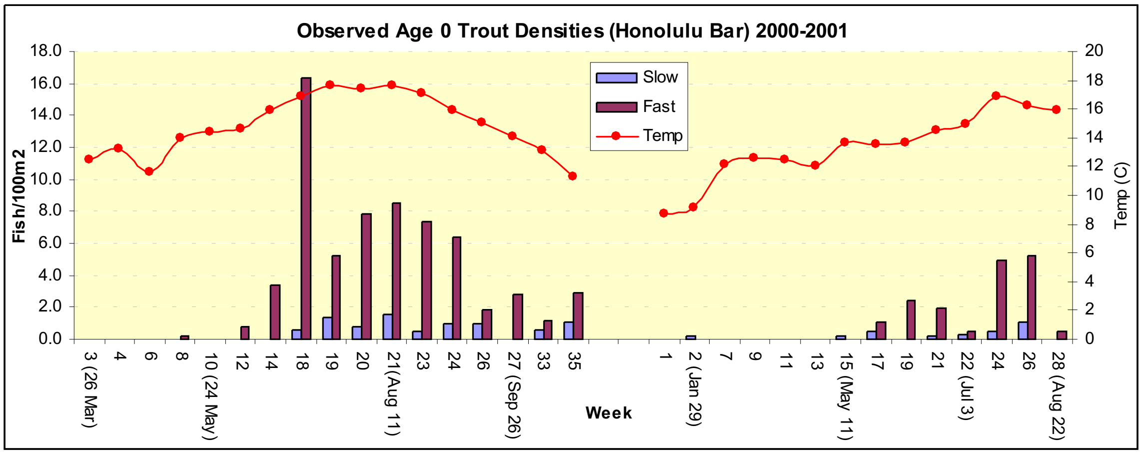
As at the upstream stations, age 0 trout first appeared in April of 2000 and 2001. Again, they were most abundant at the experimental station especially during the summer and fall. Note that surveys did not commence at the experimental station until week 16 of 2000. Densities observed were slightly higher in 2001. Water temperatures were slightly lower and flow higher in July of 2001 than 2000.

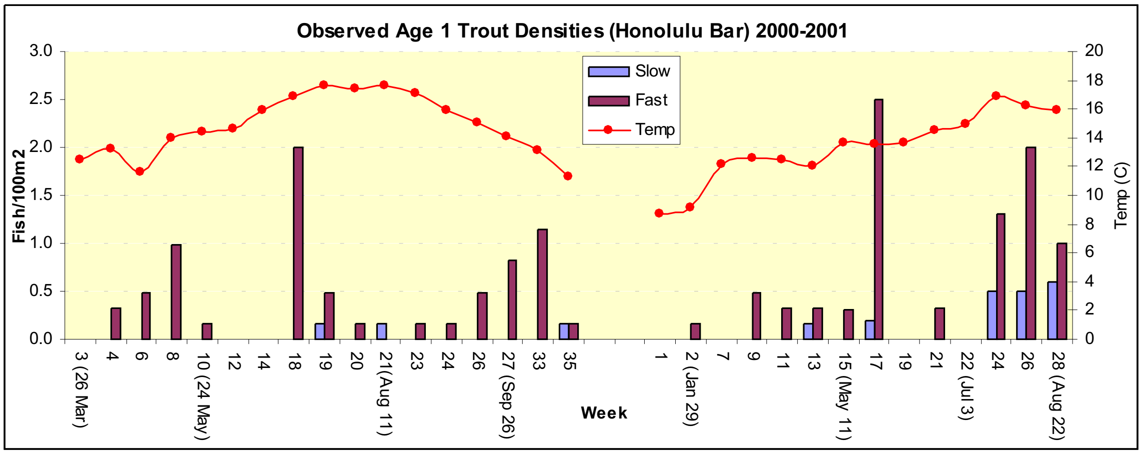
## Age 1 Trout

Age 1 trout were captured in low numbers through most of the study period. As for young, yearling densities were higher at the experimental station. Again, densities were higher in the summer of 2001 than 2000.

## Appendix E – Honolulu Bar Reach



### Juvenile Chinook Salmon

Only two sites were surveyed in the Honolulu Bar reach:  slow-water and fast-water. Again, they were far more abundant in 2001 than in 2000.  The number of young salmon observed in 2000 declined gradually through week 10.  Salmon were most abundant in the slow-water habitat.  Small numbers were observed through the summer of 2000 predominantly in the slow-water habitat.  Young salmon were abundant through mid May in 2001 after which few were observed through the summer.

No fry salmon were observed in week 37 as at the upper three stations.

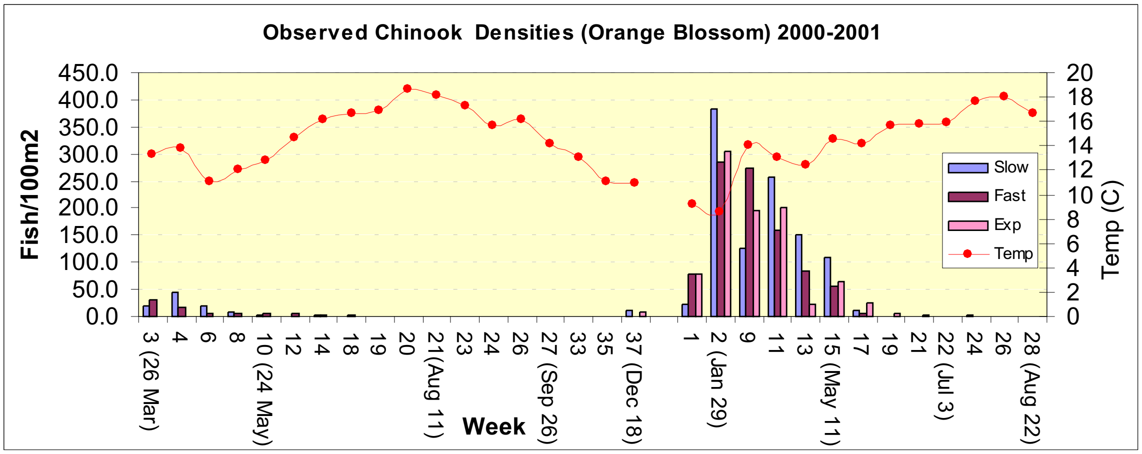
### Age 0 Trout

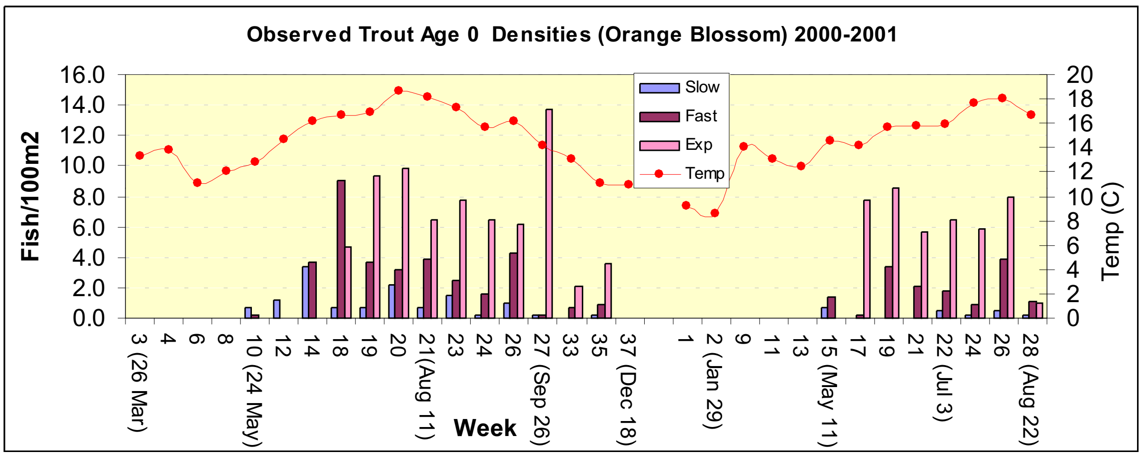
Unlike the upstream stations, age 0 trout did not appear until May in 2000 and 2001. Densities observed were higher in June 2000 despite higher water temperatures.  June flows were higher in 2000.

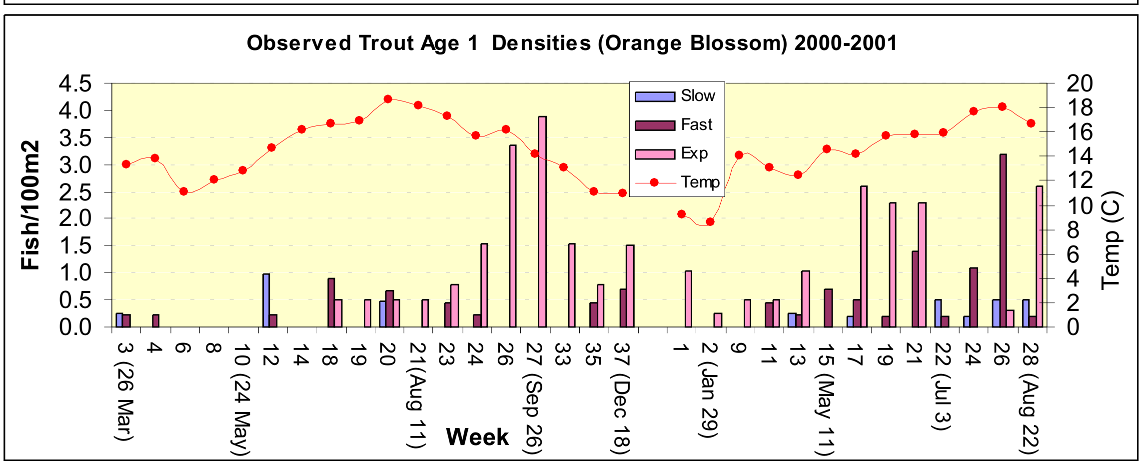
### Age 1 Trout

Age 1 trout were captured sporadically in low numbers through most of the study period. Most were observed at the slow water site.

## Appendix F - Orange Blossom Reach



### Juvenile Chinook Salmon

Three sites were surveyed in the Orange Blossom reach: slow-water, fast-water, and experimental. The experimental site was added in week 16 of 2000 after observations made during exploratory surveys in the reach indicated concentrations of juvenile salmonids at gravel introduction sites. The number of young salmon observed in 2000 declined gradually through week 18. Salmon numbers rapidly declined in both the slow and fast habitats, but particularly in the slow water habitat. Unlike the upstream experimental sites, few salmon were observed at the experimental site in 2000. A major contrast with the upper sites was the higher water temperature at Orange Blossom (> 16EC).

As at the sites previously discussed, the density of young salmon observed was again much higher in 2001 than 2000. Young salmon were not more abundant in the experimental habitat as at the upstream sites.

Some fry salmon were observed in week 37 as at the upper three stations.

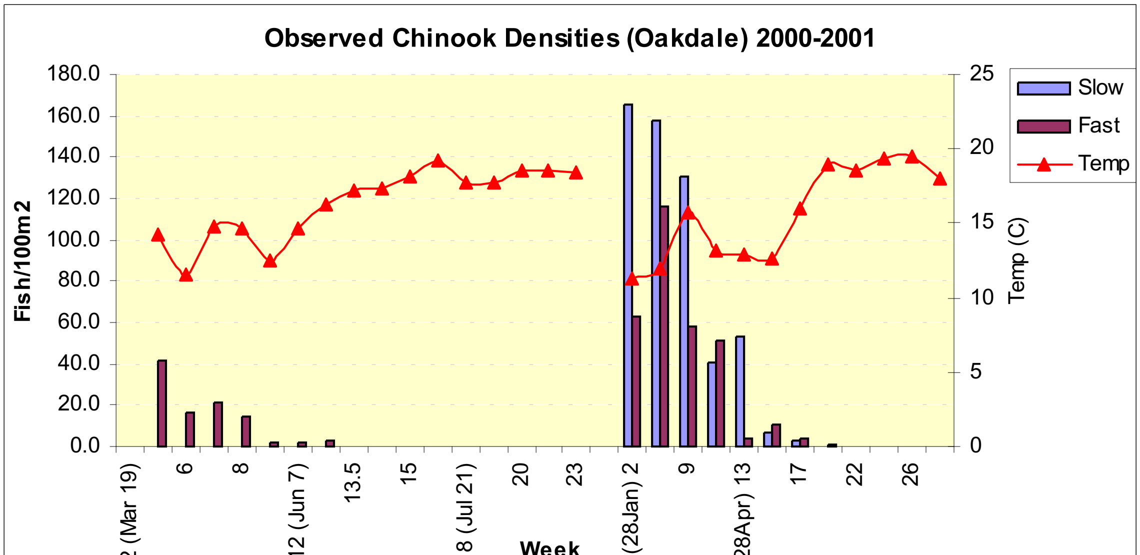
### Age 0 Trout

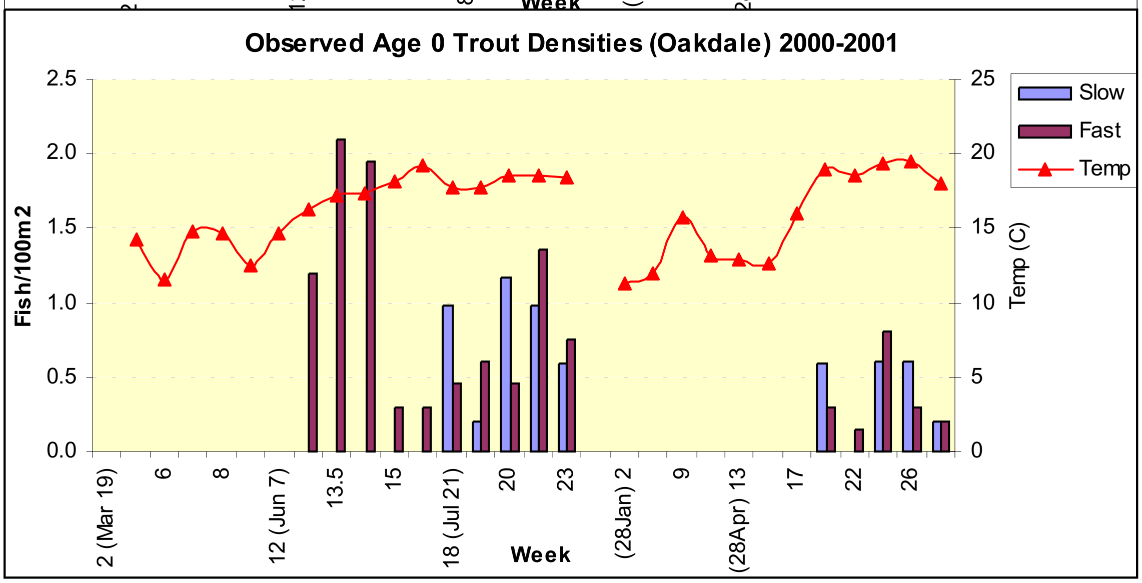
Unlike upstream stations, age 0 trout did not first appear in April of 2000 and 2001 but rather in May. Again, they were most abundant at the experimental station especially during the summer and fall. Densities observed were similar in 2000 and 2001. Water temperatures were also similar in July of the two years.

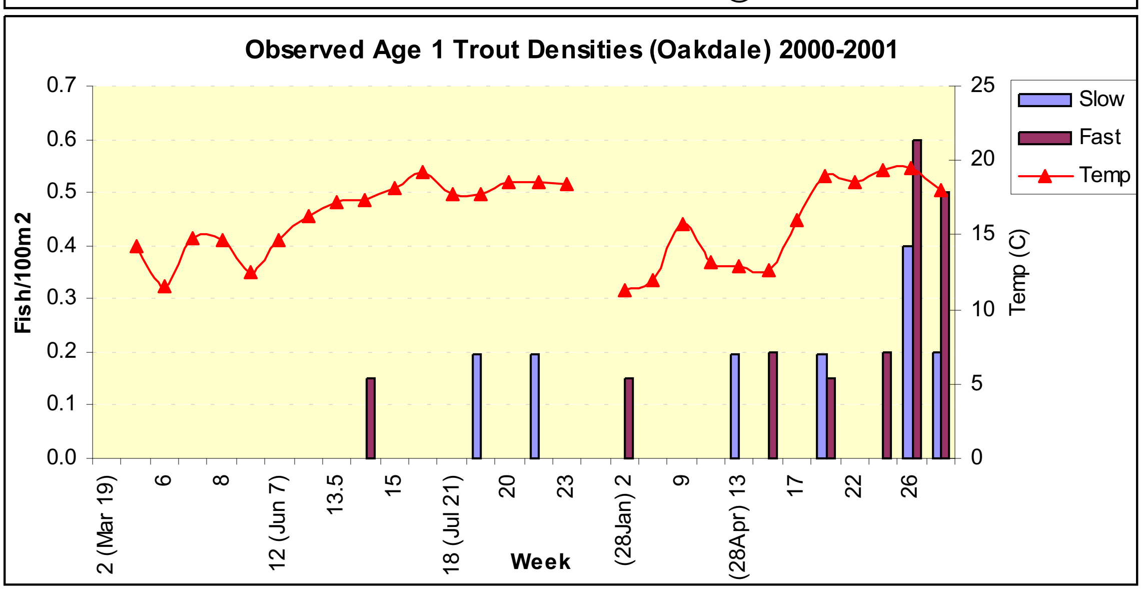
### Age 1 Trout

Age 1 trout were captured in low numbers through most of the study period. As for young, yearling densities were higher at the experimental station.

## Appendix G – Oakdale Reach



### Juvenile Chinook Salmon

Only two sites were surveyed in the Oakdale reach: slow-water and fast-water. Again, they were far more abundant in 2001 than in 2000. The number of young salmon observed in 2000 declined gradually through week 10. Salmon were most abundant in the slow-water habitat. No young salmon were observed after mid June. Young salmon were abundant through April in 2001 after which few were observed through the summer.

No fry salmon were observed in week 37 as at upstream stations.

### Age 0 Trout

Unlike the upstream stations where age 0 trout appeared in April or May, they did not appear until June at Oakdale in 2000 and 2001. Densities observed were higher in June 2000 than 2001. Water temperatures were lower in 2000 in June because June flows were higher in 2000 than 2001. Age 0 trout were initially more abundant in the slower water site, but their densities were similar late in the summer.

### Age 1 Trout

Age 1 trout were observed sporadically in very low numbers during the study period. Most were observed at the slow water site. They were more abundant in the summer of 2001 than 2000 despite water temperatures of 18-20EC.