Juvenile Chinook Habitat Use in Lower Clear Creek, 2003

Fisheries Evaluation for Phase 3A of the Lower Clear Creek Floodway Rehabilitation Project

USFWS Report

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October 2004

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The correct citation for this report is:

Newton, J. M., J. R. Grigg, and M. R. Brown. 2004. Juvenile Chinook habitat use in lower Clear Creek, 2003: fisheries evaluation for Phase 3A of the Lower Clear Creek Floodway Rehabilitation Project. USFWS Report. U.S. Fish and Wildlife Service, Red Bluff Fish and Wildlife Office, Red Bluff, California.

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Abstract.—The Lower Clear Creek Floodway Rehabilitation Project involves the phased reconstruction of the floodplain and stream channel of approximately 2 miles of Clear Creek, Shasta County, CA. Phase 3A relocated and reconstructed a 1,400 ft section of stream channel and was completed in September 2002. Phase 3A was the first project phase involving the relocation and reconstruction of the stream channel. The objective of the 2003 Habitat Use study was to determine if channel reconstruction changed habitat use by juvenile Chinook salmon *Oncorhynchus tshawytscha*. The study compared juvenile Chinook densities in the newly constructed stream channel to densities in two control reaches immediately upstream and downstream of the project boundaries. Chinook densities were determined by underwater observations within the three study reaches. We completed seven habitat use surveys between February 26 and April 17, 2003. Throughout the survey period, juvenile Chinook densities generally increased following February 26, peaked on March 10 and then declined through April 15. Densities were highest in the New Channel during the first four survey weeks. During the remaining three surveys, densities in the Lower Control reach were highest. ANOVA results suggest that densities in the New Channel may have been significantly higher than control reaches ($p=0.10$). We disproved our hypothesis that juvenile densities in the New Channel would be lower than in control reaches. This hypothesis was based on the idea that shoreline habitat in the New Channel would initially be lacking structure such as root wads, undercut banks, and aquatic vegetation and therefore would be less suitable for rearing juveniles. Higher than expected densities in the New Channel appeared to be the result of three design features: 1) an 88 m section of 18 engineered root wad and boulder clusters, 2) the old channel which was retained as a backwater, and 3) a section of floodplain vegetation captured through channel migration. Survey results did not indicate a difference in juvenile Chinook densities among most meso-habitat types. This lack of difference may be due to a poor relationship between meso-habitat types and micro-habitat characteristics in medium size creeks such as Clear Creek.

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Introduction

The Lower Clear Creek Floodway Rehabilitation Project (Project) involves the phased reconstruction of the floodplain and stream channel of approximately 2 miles of Clear Creek, Shasta County, CA (McBain & Trush et al. 2000). Phase 2 reconstructed the floodplain of most of the Project area. Phase 3A relocated and reconstructed a 1,400 ft section of stream channel and was completed in September 2002 (Figure 1). Phase 3A was the first project phase involving the relocation and reconstruction of the stream channel. The objective of the 2003 Habitat Use study was to determine, in part, if Objective F1 in the project's Ecological Monitoring Plan (BOR and WSRCD, 2000) was met. Objective F1 was to "improve salmonid rearing and spawning habitat within the project reach." The 2003 Habitat Use study was designed to compare juvenile chinook densities (i.e. habitat use) in the newly constructed stream channel to densities in two control reaches immediately upstream and downstream of the project boundaries. Our hypothesis was that, in the first year(s) following channel reconstruction, the average density of juvenile Chinook would be lower than densities in control reaches but would later increase to densities equal to or greater than control reaches. This hypothesis is based on the idea that shoreline habitat in the new channel would initially be lacking structure such as root wads, undercut banks, and aquatic vegetation and therefore would be less suitable for rearing juveniles. As riparian vegetation becomes established and woody debris is deposited in the new channel, densities of juvenile Chinook would increase.

Control reaches were chosen in order to 1) compare juvenile densities in reconstructed habitat to densities in unmodified (natural) habitat and 2) provide reference conditions to standardize study results from different years. Juvenile Chinook densities in a given stream reach can vary between years due to annual variation in 1) the temporal and spatial distribution of spawning adults, 2) juvenile production numbers, and 3) water temperatures as determined by annual variation of climate and water releases from Whiskeytown Dam.

Study Area

Clear Creek, a westside tributary to the upper Sacramento River, enters the mainstem Sacramento River at river mile (rm) 289 (river kilometer 465) near the south Redding city limits in Shasta County, California. The Lower Clear Creek Floodway Rehabilitation Project (Project) is location in the alluvial reach of Clear Creek. The alluvial reach extends upstream from the confluence with the Sacramento River to Clear Creek Road Bridge (rm 8.5). The Project extends from approximately rm 2.0 to 4.0, within which Phase 3A is located. The habitat use Lower Control Reach extended about 2,400 ft downstream from the lower Project boundary. The Upper Control Reach extended about 3,500 ft upstream from the upper Project boundary.

Methods

Three stream reaches were chosen to evaluate habitat use by juvenile Chinook; the newly constructed channel, an upper control reach, and a lower control reach. Control reaches were chosen outside the project boundaries so that they could be used in all future habitat use studies evaluating current and future project phases involving stream channel reconstruction. Control reaches were located as close as possible to the project boundaries so spawning densities and water temperatures would be as similar as possible to the project area.

Modifications to past habitat use study protocols used by the Red Bluff Fish & Wildlife Office (RBFWO) were made for the 2003 study. These modification included limiting estimation of juvenile densities to shoreline habitat in the main channel, thereby discontinuing the estimation of transect (i.e. mid-channel) densities. Also, juvenile density at a given location and time was determined by a single count, discontinuing replicate counts by two observers. These modifications resulted in a significant savings of time and money thereby allowing for multiple surveys to be completed during the 2003 rearing season. Due to these modifications, we did not extrapolate densities to the entire wetted area or to a total number of fish per reach.

Habitat Typing

Before the start of the survey period field crews mapped meso-habitat units (habitat typing) in each of the three reaches. Habitat typing categories used for this study were modeled after California Salmonid Stream Habitat Restoration Manual (CDFG 1998). The types used in our study were taken from the level II and III habitat typing categories and included main channel run, riffle, glide, and pool; side-channel run, riffle, glide and pool; and backwaters. In addition to these stream-channel habitat types, we included a degraded type called moonscape which is characteristic of much of the degraded habitat in the restoration reach. Moonscape is: 1) a braided stream channel at low flows; 2) has a predominantly clay hard-pan substrate with very little spawning gravel; 3) has a higher gradient relative to habitat types in the alluvial reach of the creek; and 4) often has turbulent surface flow. The boundaries of these individual units were marked on aerial photos and those breaks were marked with numbered flagging to indicate to the field crew the beginning and end of each unit. Widths and lengths of theses units were taken with a tape measure or laser range finder. Length of the unit was recorded down the center of the channel and several widths were measured and an average recorded. Surface area of the entire unit was recorded, as well as the surface area of the area in which under water observations would occur.

Prior to each weekly survey, field crews would revisit each unit, assess the channel at the current flow and adjust reach breaks or habitat type designations as needed. These changes in type and length were recorded and applied to that days chinook numbers to calculate the density for that specific survey.

Underwater Observations

Habitat use surveys.— Underwater observations of habitat use were made in all habitat units within the New Channel reach. In the upper and lower control reaches, representative habitat units within each type (e.g. pools, riffles, etc.) were selected. The number of juvenile Chinook seen during snorkeling in each habitat unit was recorded. Juveniles were classified as small (<50 mm) or large (>50 mm). The density of juvenile Chinook was calculated for an entire reach as well as for each habitat unit. Densities were calculated for separate and combined size classes.

Prior to each survey, observers calibrated their eyes using silhouettes of juvenile fish of varying sizes, suspended in the water column by a bobber, fishing line and a weight. During the surveys, two hand held counters were used to record the number of juvenile chinook in each of the size categories.

Two methods were used to count juvenile Chinook; shoreline counts and total counts.

Shoreline counts were performed in main channel habitat types including pools, glides, runs and riffles. Shoreline counts were conducted throughout the entire length of a habitat unit in a 1.83 m (6 ft) wide zone between observer and shoreline. Total counts were performed in backwaters and all side channel habitats. Total counts enumerated all juveniles throughout the entire area of the habitat unit. Depending on water velocity, depth, and instream structure, observers would float downstream or pull themselves upstream using ropes, substrate, or rooted vegetation. Surveyors rated each count as good, fair, or poor. A poor rating indicated that the surveyor was sure he missed fish. A fair rating means that the surveyor felt there was a possibility they might of missed fish and a good survey was used when the surveyor felt all fish were counted. Poor observations were not included in the data analysis.

Focused study 1: observer bias.—Additional to the regular habitat use surveys, a focused study was performed on March 19th to evaluate potential bias between our two individual observers. For this study, 16 habitat units were selected for the two individuals to perform replicate shoreline counts. Each unit was undisturbed for 10 minutes in between replicate counts. Observers alternated who went first to eliminate the confounding variable of observer order. The data was also analyzed to determine if there was an effect of observer order (1st vs. 2nd). Methods used prior to the 2003 study calculated densities based on the average of two replicate counts.

Focused study 2: diurnal variability.—The diurnal variability study was designed to evaluate the change in juvenile densities within a habitat type or within an individual habitat unit throughout the day. A pilot study was conducted on March 18th to determine densities at three different times of day; approximately 09:00, 12:00, and 14:00. On April 17 a full diurnal variability study was conducted which evaluated densities for five different time slots; approximately 08:00, 10:00, 12:00, 14:00, and 16:00.

Results

Habitat Typing

Habitat typing of the three survey reaches was conducted at flows ranging from approximately 235 to 375 cubic feet per second (cfs). In only three instances was a unit reclassified as a different habitat type due to changes in flow. Lengths of some habitat units were adjusted slightly in response to flow changes. Run habitat was most prevalent in the control reaches but riffle habitat was most prevalent in the New Channel (Table 1).

Underwater Observations

Habitat use surveys.—We completed seven habitat use surveys and three focused studies between February 26 and April 17, 2003 (Table 2). During surveys, mean daily temperatures ranged from 46 to 54°F, flows ranged from 239 to 375 cfs, and water turbidity ranged from 1.2 to 2.0 NTU. Habitat use observations were made in 100% of the New Channel meso-habitat units, 79% of the Upper Control Reach units, and 65% of the Lower Control Reach units. On average, a total area of 8,038 m^2 in 52 habitat units were surveyed each week (Table 1). For quality of observation rating within units, 87% were good, 12% were fair, and 1% were poor.

Surveys were conducted between the hours of 8:30 AM and 3:30 PM. We attempted to vary the time of day during which a particular reach was surveyed. Thus, percentage of surveys conducted before noon and after noon were 58% and 42 % for the Upper Control Reach, 40%

and 60% for the New Channel, and 96% and 4 % for the Lower Control Reach (Figure 2).

Throughout the survey period, juvenile Chinook densities generally increased following February 26, peaked on March 10 and then declined through April 15 (Figure 3). During the peak survey week, densities in the three reaches ranged from 2.16 to 2.67 fish/m^2. We calculated the grand density for each reach in each survey week. The grand density is the total number of fish counted in the entire reach divided by the total area surveyed in the reach. Grand densities were highest in the New Channel during the 1st four survey weeks and were highest in the Lower Control Reach during the final three survey weeks (Figure 3). We used a Randomized Block ANOVA test to evaluate grand density data. Grand densities in the New Channel, Upper Control and Lower Control reaches were significantly different at a significance level of α=0.10 (p=0.10). Pair-wise comparisons revealed that the New Channel and Upper Control Reach densities were the most different and the control reach densities were the most similar.

In addition to grand densities, we calculated average densities for each reach based on meso-habitat unit densities. Results were somewhat different than grand densities. Average densities during the first two survey weeks were highest in the New Channel. During the remaining five surveys, average densities in the Lower Control reach were highest (Figure 4). Results from a two-factor ANOVA showed that there was a significant difference in densities among survey weeks (p=0.000) but not among reaches (p=0.267).

Regarding habitat types, average juvenile Chinook densities were highest in backwaters followed by equal densities in glide and riffle habitat (Figure 5). On average, the lowest densities were observed in side channel riffle and side channel run habitat. ANOVA results showed that there was a significant difference between types (p=0.018). The followup test, Tukey HSD Multiple Comparison, indicated that this difference was only between backwaters vs side channel riffles (p=0.020) and backwaters vs side channel runs (p=0.026). Side channel riffles and runs were extremely rare in our survey area, together accounting for only 7 of the 361 observations, suggesting generalization of these results to all of lower Clear Creek may not be warranted. Additionally, side channel riffles were very shallow requiring fish counts to be made out of the water, possibly decreasing observed densities. Densities in main channel habitats were higher than side channel habitats (p=0.003).

Within the New Channel, reconstruction and channel placement activities left sections of stream bank devoid of vegetation. We expected juvenile densities in the New Channel would therefor be relatively low until riparian vegetation could become established. Some sections in the new channel did have riparian structure following construction, including an 88 m section with 18 engineered root wad and boulder clusters (Figure 6a), the north bank of the old channel which was retained as a backwater (Figure 6b), and a section of captured floodplain vegetation resulting from channel migration (Figure 6c). Within New Channel habitats, average juvenile Chinook densities were significantly different (p=0.000) between units with riparian structure (3.66 fish/m^2) and units without riparian structure (0.45 fish/m^2).

The ratio of large to small juvenile chinook was heavily skewed towards the small fish during the first three surveys of the season and ranged from 1:592 to 1:696 (Table 3). As newly emergent juveniles grew, the ratio was much more balanced during the latter four surveys of the season and ranged from 1:20 down to 1:3 (Table 3). A substantial shift in the ratio of large to small juveniles occurred between the March 10 and March 24 surveys.

Focused study 1: observer bias.—The observer bias focused study was to determine if juvenile Chinook counts differed between our two observers, Casey Del Real and Josh Grigg, and to determine if there was a difference between the 1st and 2nd observer in replicate counts.

Paired t test results indicated that there was no statistical difference between Josh and Casey's counts (p=0.429; Figure 7) and that there was no difference between the 1st and 2nd observer (p=0.165; Figure 8).

Focused study 2: diurnal variability.—Eleven habitat units were surveyed five times each on April 17. Survey time categories were 09:00, 10:00, 12:00, 14:00, and 15:30. Average densities for the five time periods ranged from 1.2 to 1.9 with the highest being the 1st survey of the day (09:00) and the lowest being the 2nd survey of the day (10:00, Figure 9). A pilot study was conducted on March 18 with three replicate counts at 10:00, 12:30, and 15:00. Average densities for the three time periods ranged from 2.2 to 3.0 with the lowest being the 1st survey of the day (10:00) and the highest being the 2nd survey of the day (12:30, Figure 10). No definite pattern or trend was detected for diurnal changes in fish densities. Within individual habitat units, diurnal variability was sometimes quite high. The maximum range for an individual unit was 6.9 fish/m^2.

Discussion

Juvenile Chinook grand densities were generally highest in the New Channel and lowest in the Upper Control Reach. ANOVA results showed that grand densities were statistically different among reaches at the α=0.10 significance level. A similar comparison was performed based on densities calculated for each meso-habitat unit and differences among reaches were not statistically significant. Due to the patchy distribution of juvenile Chinook, sampling based on relatively small meso-habitat units led to large variability in our data set. Habitat unit densities ranged approximately three orders of magnitude during a survey week. This variability made determining if there was a difference between the New Channel reach and control reaches unlikely. This variability is reduced in the grand densities which reduce the data set to only seven data points per reach. Very high juvenile densities in a few New Channel units early in the season may have been responsible for the statistical difference.

The statistical difference is contrary to the initial hypothesis that following channel reconstruction, the average density of juvenile Chinook would be lower than densities in control reaches. Some important channel design features increased structural complexity and resulted in higher densities than predicted. General observations indicated juveniles were more abundant in areas with structure (e.g. root wads, riparian vegetation, debris jams) and some depth (e.g. >0.1 m). To investigate this we classified New Channel habitat units as "with" or "without" structure. Average densities were 8 times greater in units with structure. Some structure included in the construction design of the New Channel appeared successful at providing high quality juvenile habitat:1) an 88 m section of engineered root wad and boulder clusters designed to prevent the stream from occupying the old channel (Figure 6 area A), 2) the old channel which was retained as a backwater (Figure 6 area B), and 3) an outside bend of the new channel which was directed towards a band of mature vegetation on the floodplain (Figure 6 area C). As planned, the bend migrated laterally into the vegetation which stabilized the channel and provided juvenile habitat.

The root wad area contained 3.1 times the average juvenile density in all reaches. The backwater areas with retained riparian vegetation had 1.5 times the average density. The captured floodplain vegetation had 5.6 times the average density.

The floodplain scour channel associated with the New Channel was not watered at flow levels during our study and therefore did not provide juvenile habitat. The alcoves designed and built in the New Channel were largely obliterated by high stream flows and did not provide significant habitat. Stratifying sampling units by instream structure and possibly other microhabitat-shoreline features may reduce variability in the data.

Juvenile Chinook density did not appear related to meso-habitat types (with the possible exception of two rare side channel types). We suspect that, in medium size creeks such as Clear Creek with widths ranging from approx. 20 to 30 m, micro-habitats suitable for juvenile Chinook are not well correlated to meso-habitat types. For example, in riffle habitat, the shoreline of some units was uniformly shallow with swift turbulent water and low densities of juvenile Chinook Other riffle units had shorelines containing small areas with greater depth and lower velocity occupied by relatively high densities of juvenile Chinook.

The Observer Bias Focused Study indicated that there was no significant difference between our two observers, Casey Del Real and Josh Grigg. The study also showed that there was no significant difference between the 1st and 2nd observers in replicate counts. Therefore, our change in protocol in 2003 to using only one observer per habitat unit instead of two (i.e. no replicate counts) likely had no influences on the density data.

The Diurnal Variability Focused Study demonstrated that diurnal fluctuations within a given habitat unit is a source of variability in habitat use data. Yet, diurnal variability within a habitat unit is much less than the variability between units ($p=0.000$).

References

BOR and WSRCD (U.S. Bureau of Reclamation, Western Shasta Resource Conservation District). 2000. Ecological monitoring plan for lower Clear Creek floodway rehabilitation project. Report to CALFED Bay Delta Program.

CDFG (California Department of Fish and Game). 1998. California Salmonid Stream Habitat Restoration Manual. Prepared by the Inland Fisheries Division. Sacramento, CA.

McBain and Trush, Graham Matthews and Associates, and North State Resources. 2000. Lower Clear Creek floodway rehabilitation project: channel reconstruction, riparian vegetation, and wetland creation design document. Report to the Clear Creek Restoration Team.

Tables

TABLE 1.—Average area, percent of total area by reach, and number of habitat units for meso-habitat types during juvenile Chinook habitat use surveys in Clear Creek conducted in 2003.

	Habitat available by reach			Habitat sampled by reach		
	Lower control	New channel	Upper control	Lower control	New channel	Upper control
Riffle						
Area (m^2)	592	4,037	1,987	44	452	279
Area (%)	6	33	9	3	15	8
Number of units	3	3	4	2	3	4
Run						
Area (m^2)	3,491	1,252	13,615	511	201	649
Area (%)	32	10	64	31	7	20
Number of units	8	3	5	4	3	2
Glide						
Area (m^2)	2,530	932	1,979	358	155	285
Area (%)	24	8	9	22	5	9
Number of units	4	3	3	3	3	3
Pool						
Area (m^2)	2,660	2,393	350	284	365	64
Area (%)	25	20	2	17	12	2
Number of units	4	1	1	2	1	1
Moonscape						
Area (m^2)	1,344	192	1,297	302	43	229
Area (%)	12	2	6	18	1	7
Number of units	1	1	1	1	1	1
Backwater						
Area (m^2)	60	2,797	69	60	1,704	69
Area (%)	1	23	0.3	4	55	2
Number of units	2	7	1	2	7	1
Side channel riffle						
Area (m^2)	0	624	513	0	173	508
Area (%)	0	5	2	0	6	15
Number of units	0	1	3	0	1	3
Side channel run						
Area (m^2)	76	0	1,237	76	0	975
Area (%)	1	0	6	5	0	29
Number of units	1	0	3	1	0	2
Side channel glide						
Area (m^2)	0	0	180	0	0	144
Area (%)	0	0	1	0	0	4
Number of units	0	0	2	0	0	1
Side channel pool						
Area (m^2)	0	0	108	0	0	108
Area (%)	0	0	1	0	0	3
Number of units	0	0	1	0	0	1
Total area (m^2)	10,753	12,226	21,334	1,635	3,093	3,310
Total units	23	19	24	15	19	19

TABLE 2.—Habitat use surveys and associated environmental conditions including mean daily temperatures (°F) at the New Channel reach, mean daily flows at the Igo gaging station (cfs), and turbidity (NTU).

Survey	Date	Mean daily temp (°F)	Mean daily flow (cfs)	Turbidity (NTU)
Survey 1	02/26-27/2003	48	250	1.3
Survey 2	03/03-04/2003	47	244	1.3
Survey 3	03/10-11/2003	48	239	1.2
Diurnal variability pilot study	03/18/2003	46	315	1.5
Observer bias study	03/19/2003	47	300	
Survey 4	03/24-25/2003	50	270	1.3
Survey 5	04/02-03/2003	54	250	1.4
Survey 6	04/07-08/2003	53	248	1.2
Survey 7	04/15-16/2003	51	375	2.0
Diurnal variability study	04/17/2003	50	339	

TABLE 3.—Ratio of large (>50 mm) to small (<50 mm) juvenile Chinook during seven habitat use surveys in Clear Creek.

Ratio	02/26/2003	03/03/2003	03/10/2003	03/24/2003	04/02/2003	04/07/2003	04/15/2003
Large : Small	1:592	1:696	1:694	1:20	1:5	1:5	1:3

Figures

A

B

FIGURE 1: Aerial photographs of Phase 3A channel reconstruction site of the Lower Clear Creek Floodway Rehabilitation Project in 1997 (**A**, pre-construction) and in 2002 (**B**, post-construction).

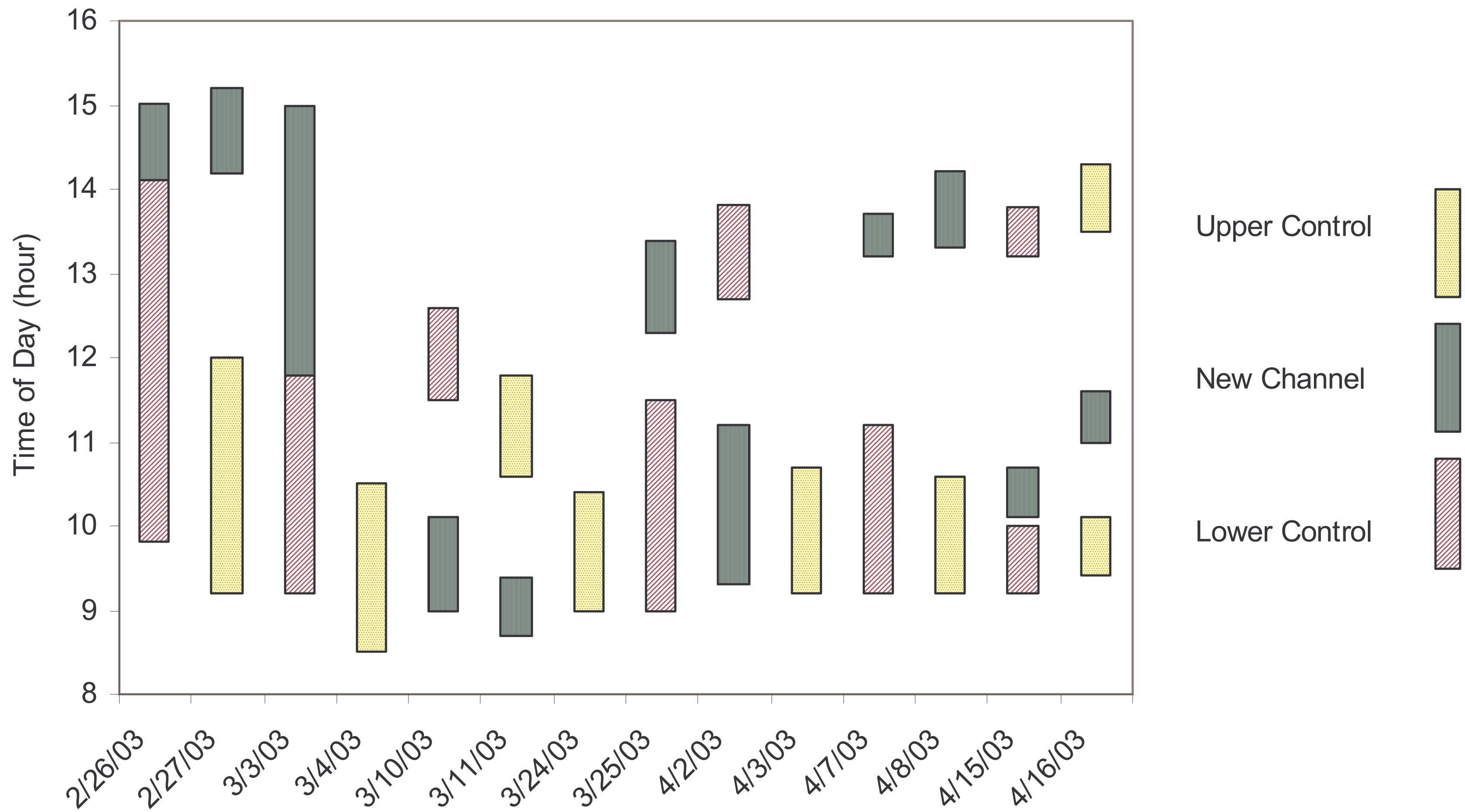

FIGURE 2: The time of day during which juvenile Chinook habitat use surveys were conducted within three different reaches on Clear Creek in 2003.

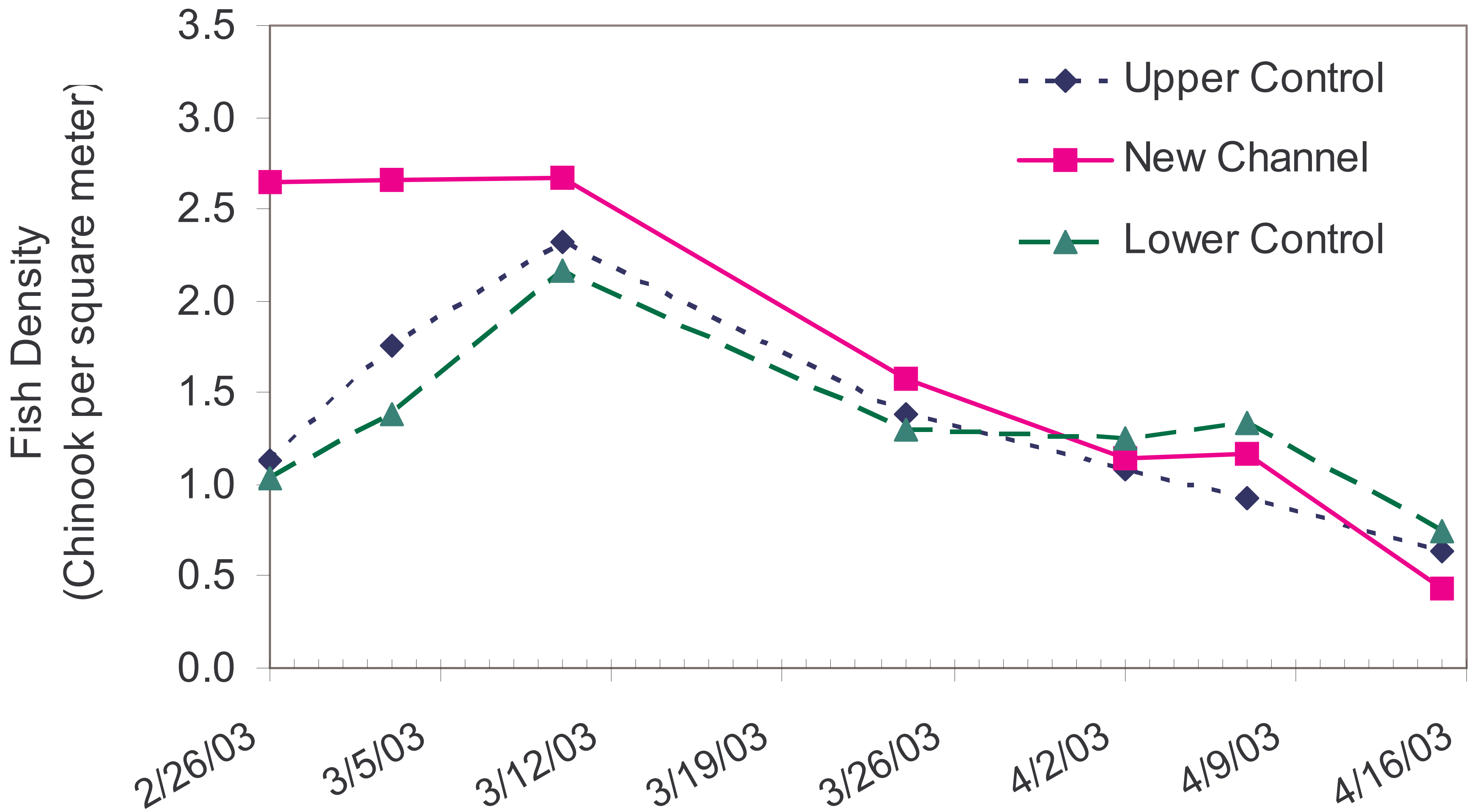

FIGURE 3: Juvenile Chinook grand densities (no averaging) in the Upper Control, New Channel, and Lower Control reaches during seven habitat use surveys on Clear Creek in 2003.

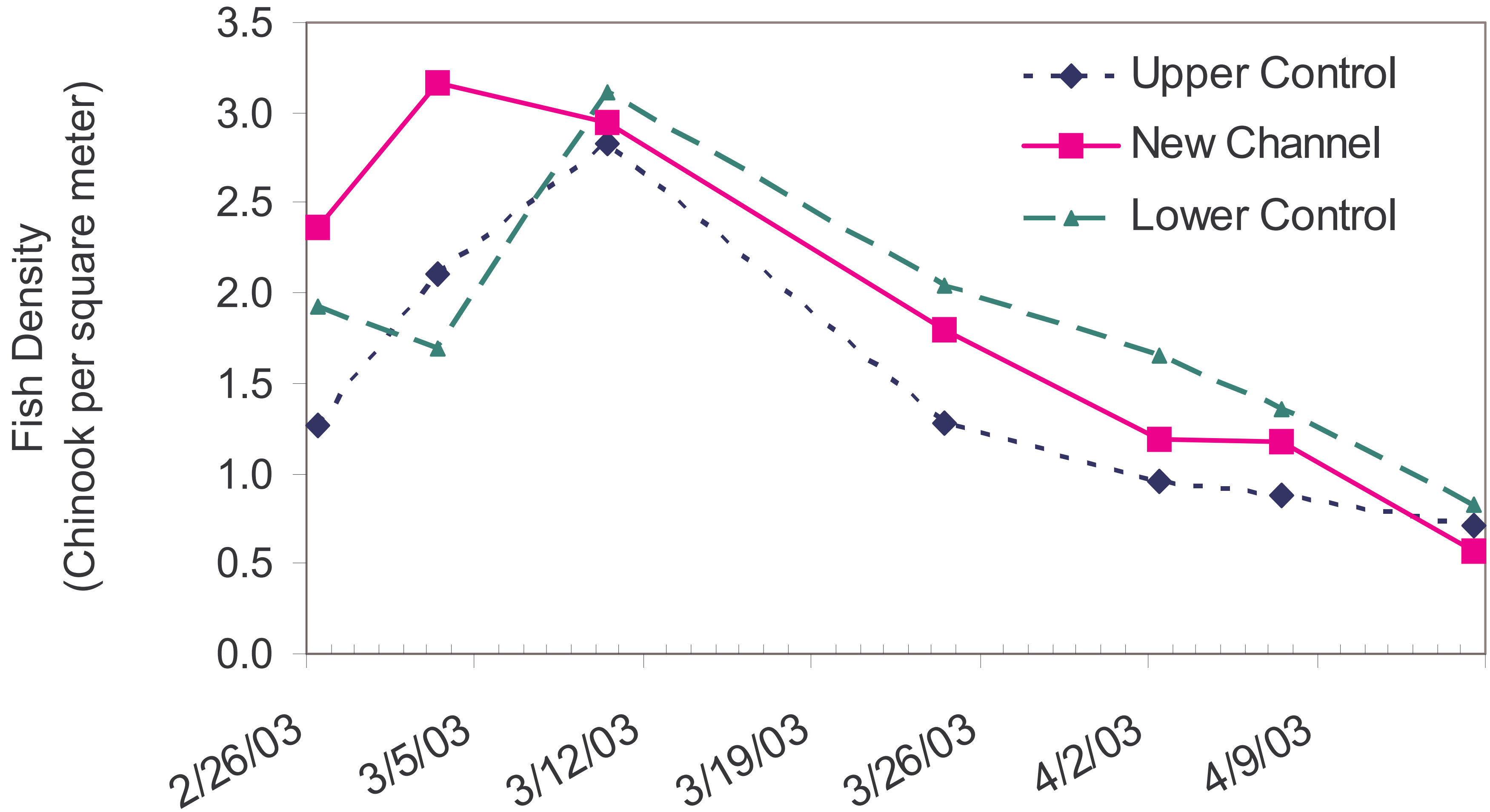

FIGURE 4: Average juvenile Chinook densities in meso-habitat units of the Upper Control, New Channel, and Lower Control reaches during seven habitat use surveys on Clear Creek in 2003.

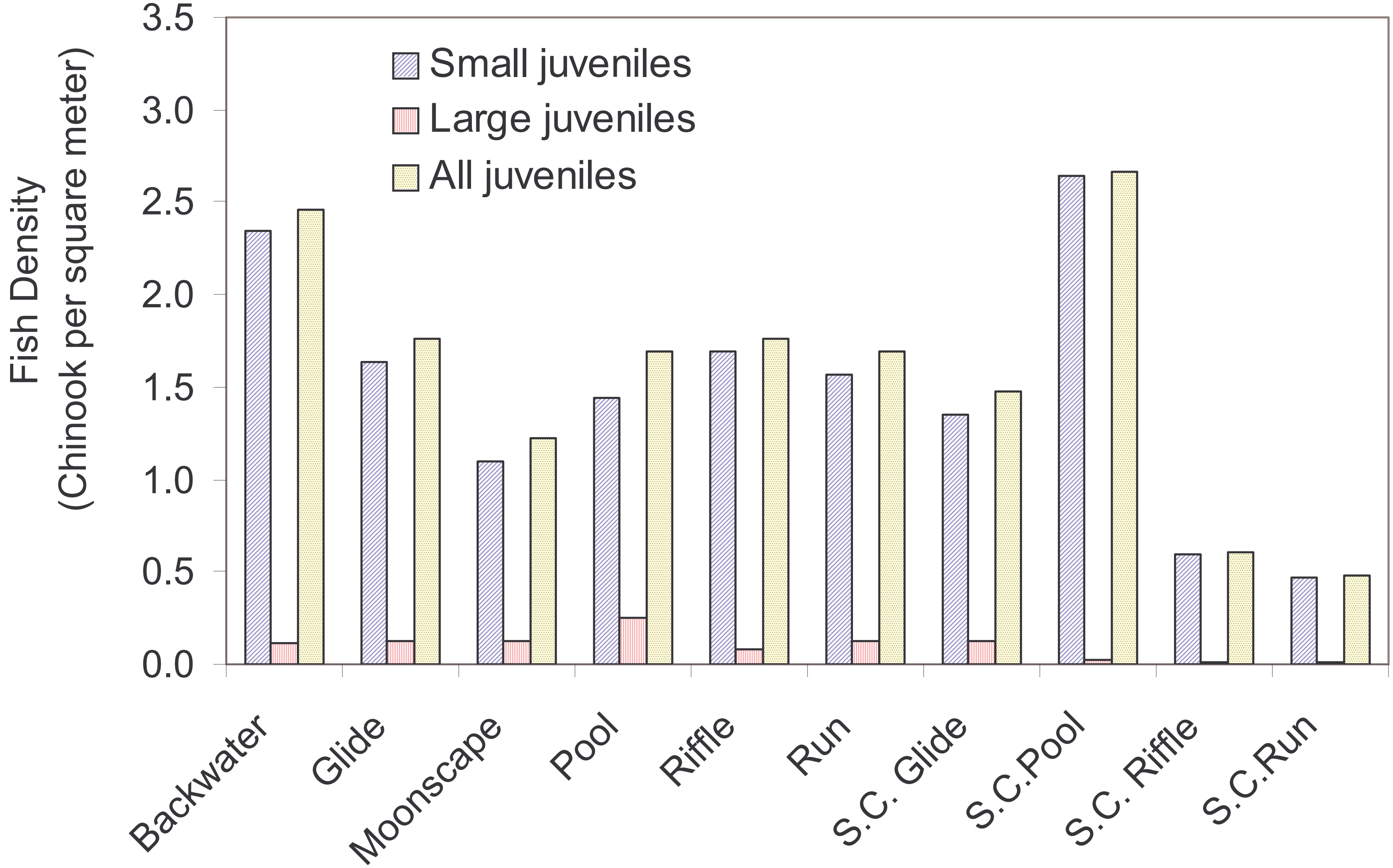

FIGURE 5: Average juvenile Chinook densities within main channel and side channel (S.C.) habitat types during habitat use surveys on Clear Creek in 2003.

FIGURE 6: Reconstructed New Channel (Phase 3A) on Clear Creek in 2003. Circles highlight areas with riparian structure high densities of juvenile Chinook, including 18 engineered root wad and boulder clusters (A), the north bank of the old channel which was retained as a backwater (B), and a section of captured floodplain vegetation resulting from channel migration).

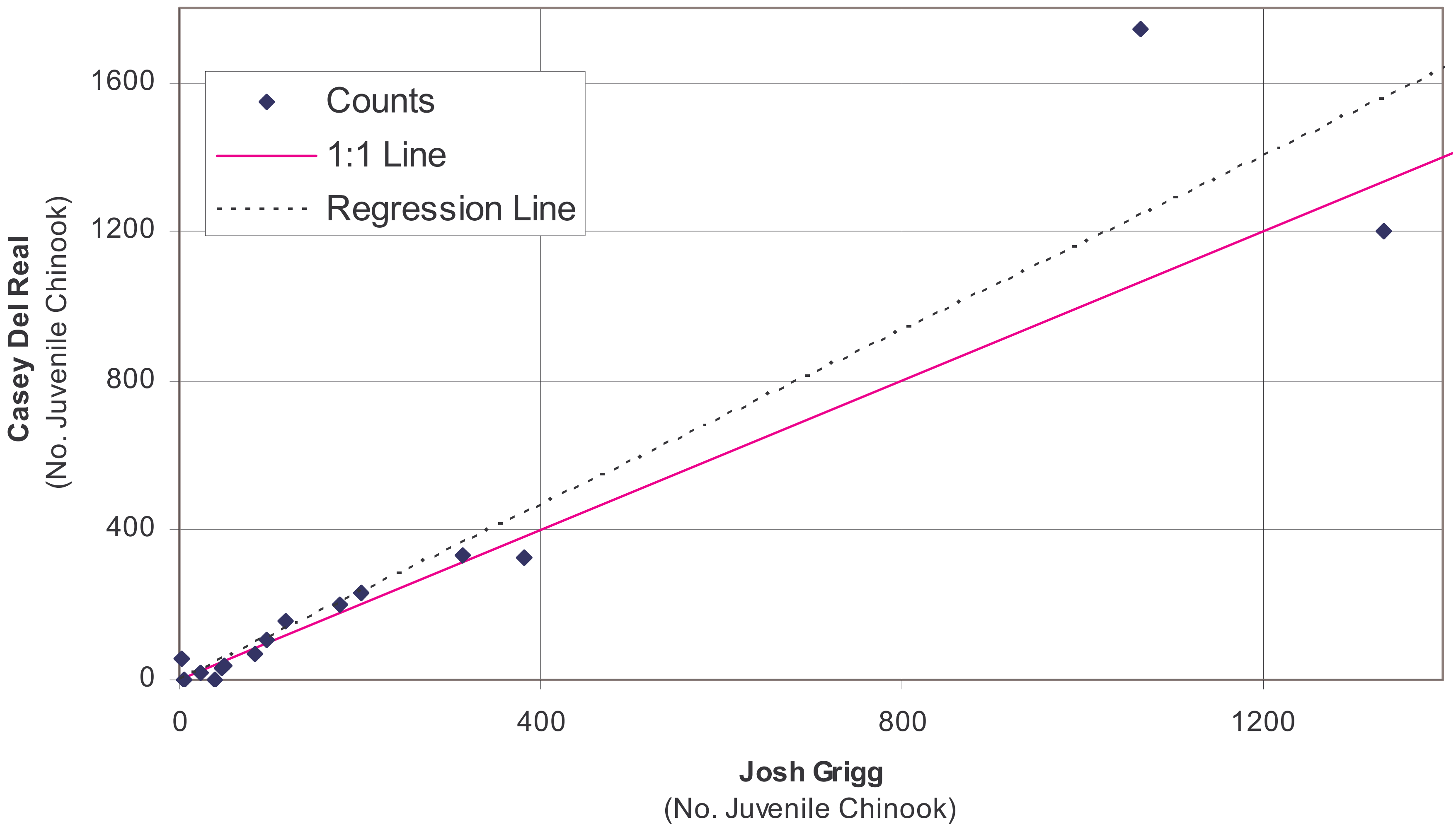

FIGURE 7: Observer Bias Focused Study comparing replicate counts of juvenile Chinook by two observers (Casey Del Real and Josh Grigg) in 15 habitat units.

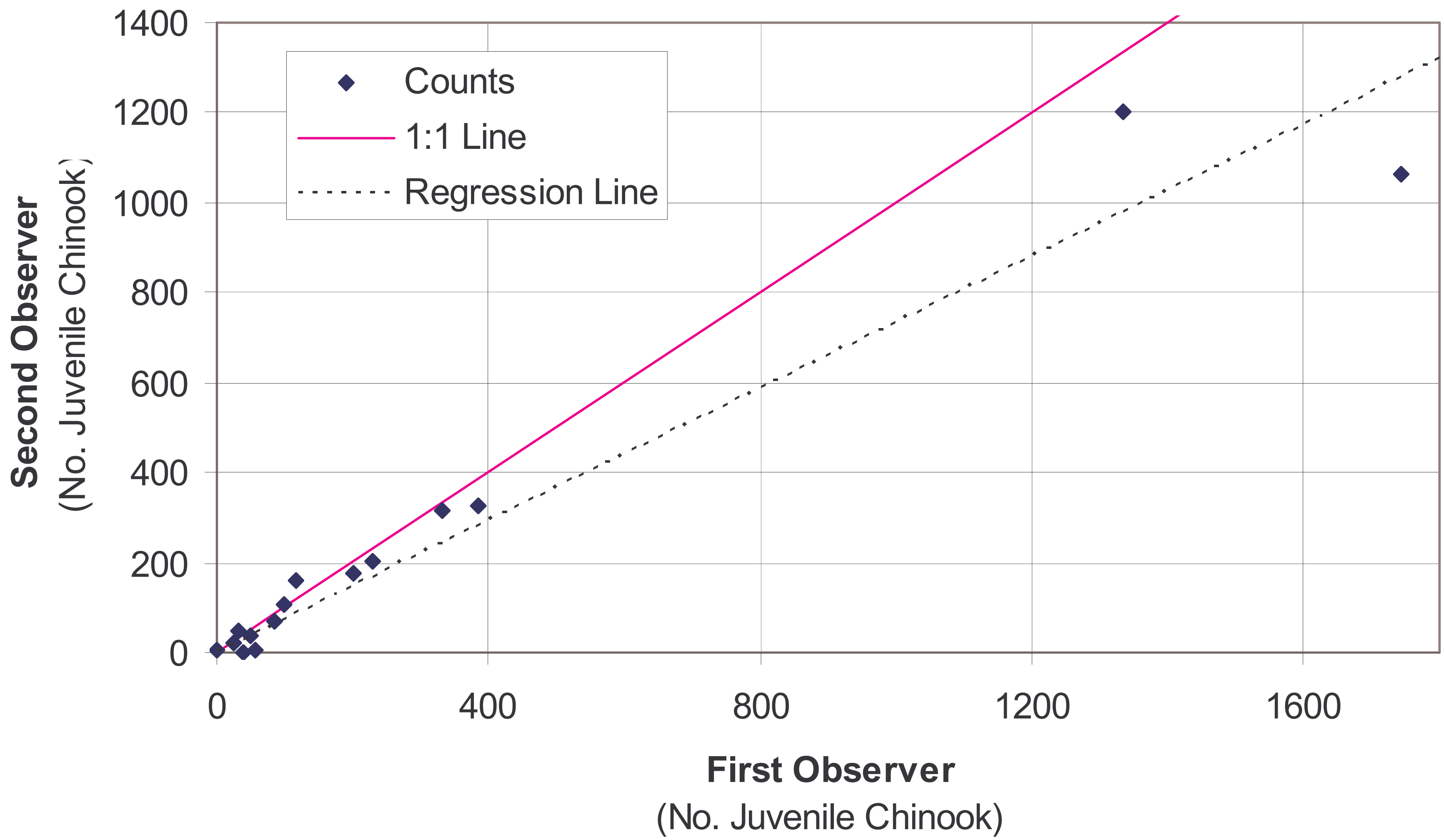

FIGURE 8: Observer Bias Focused Study comparing replicate counts of juvenile Chinook by the first observer and the second observer in 15 habitat units.

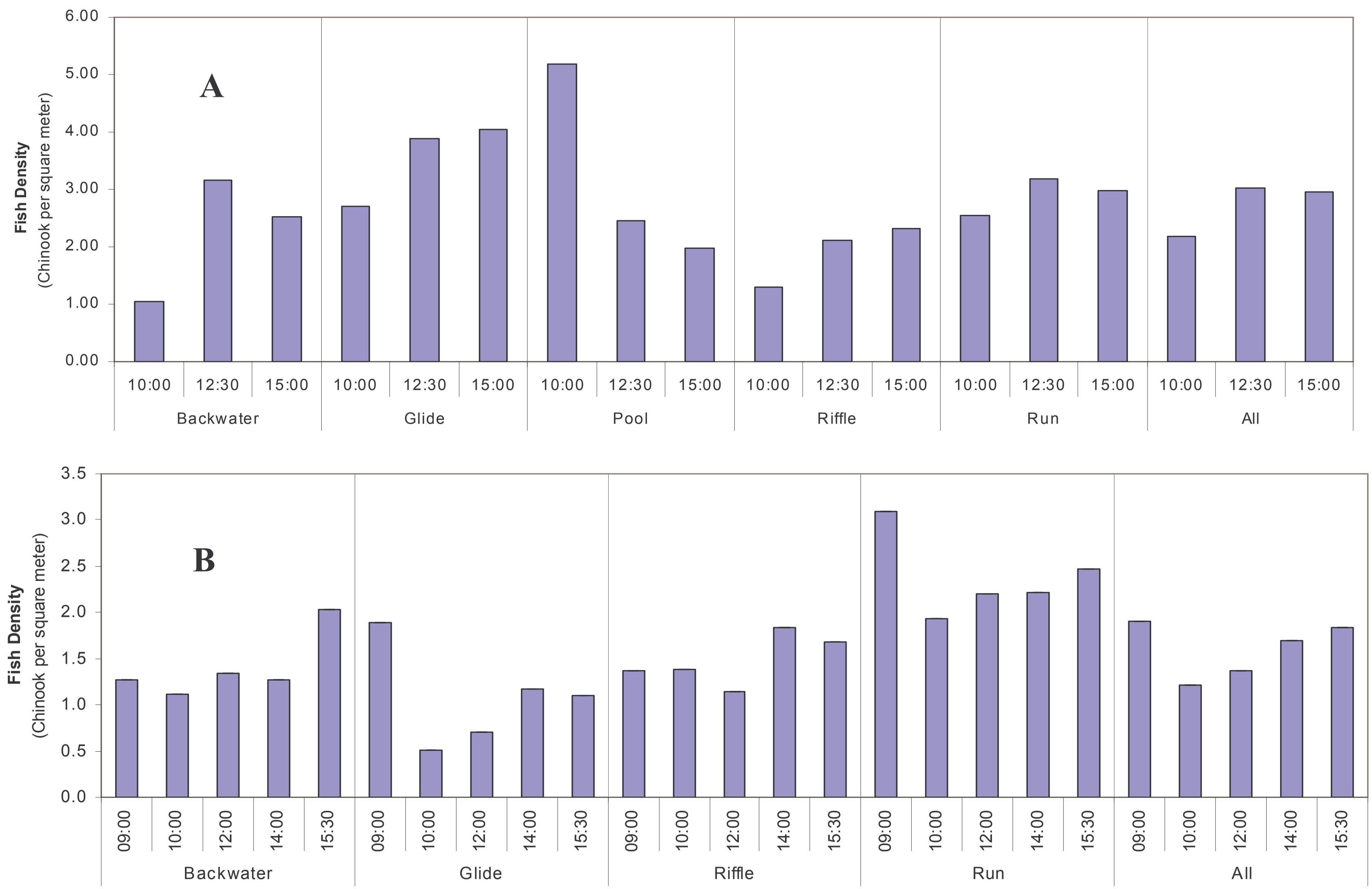

FIGURE 9: Average juvenile Chinook densities by habitat type and time of day for two Diurnal Variability Focused Studies including **(A)** a pilot study on March 18, 2003 with three replicates in 13 habitat units and (**B**) a full study on April 17 with five replicates in 11 habitat units.