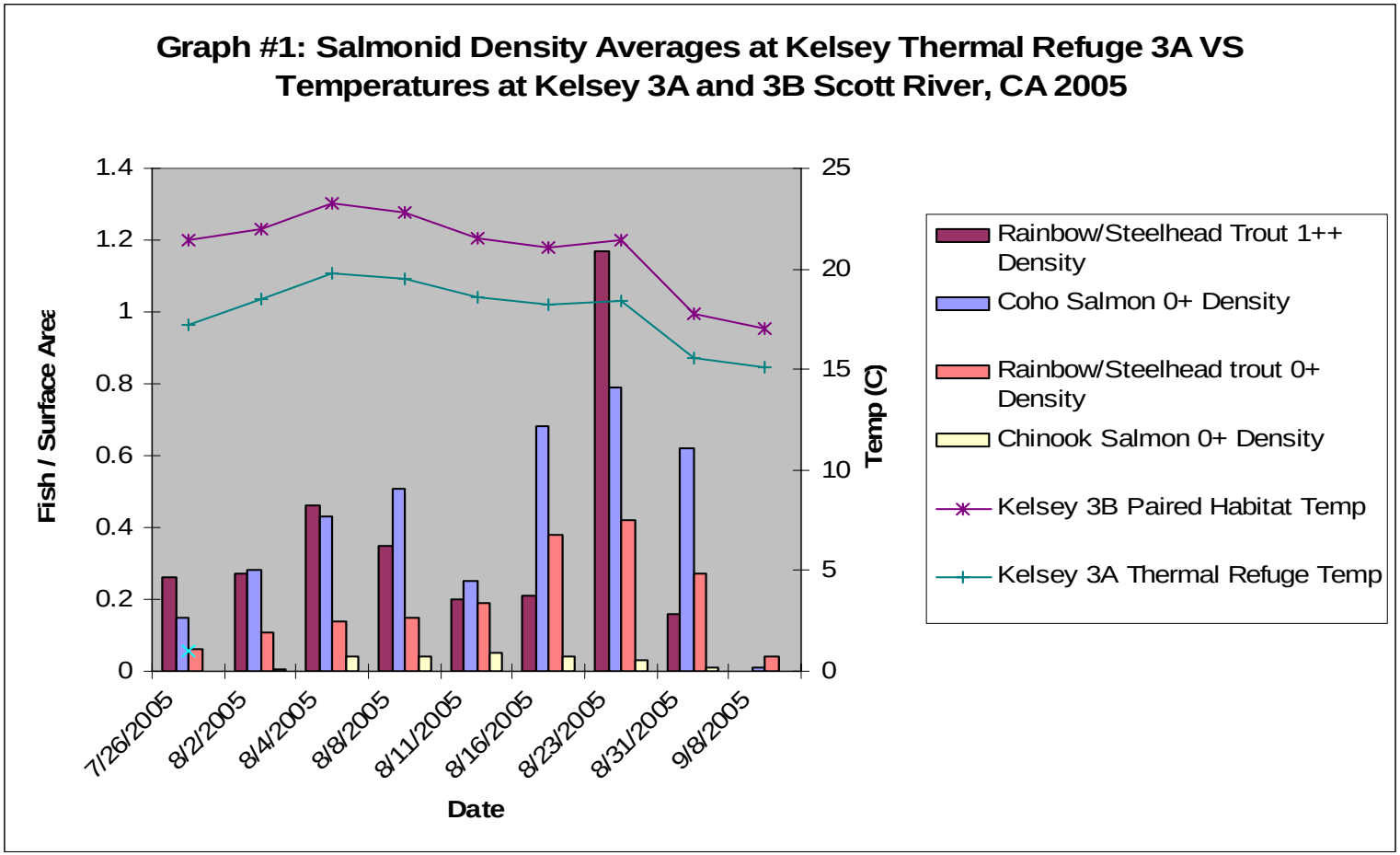
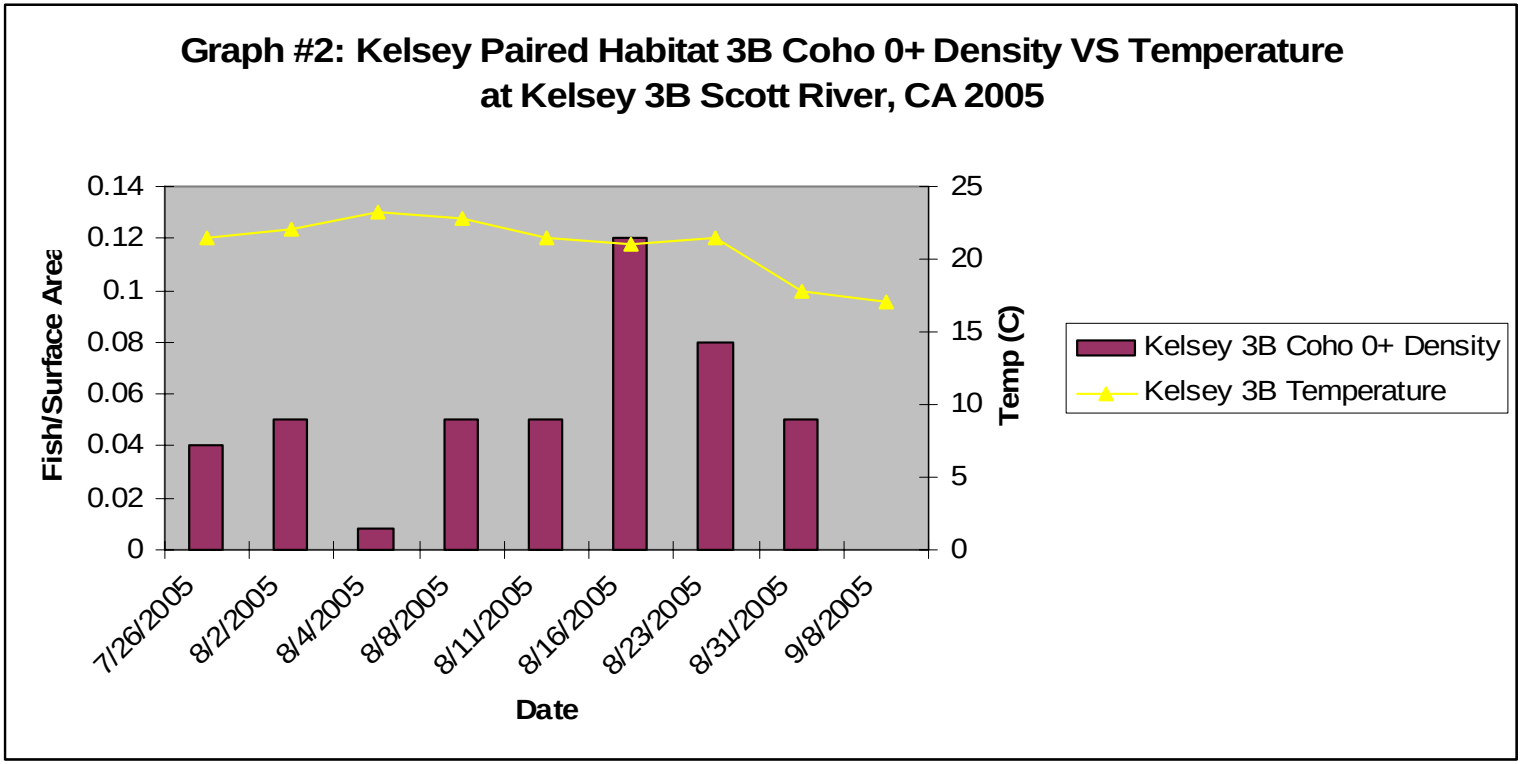


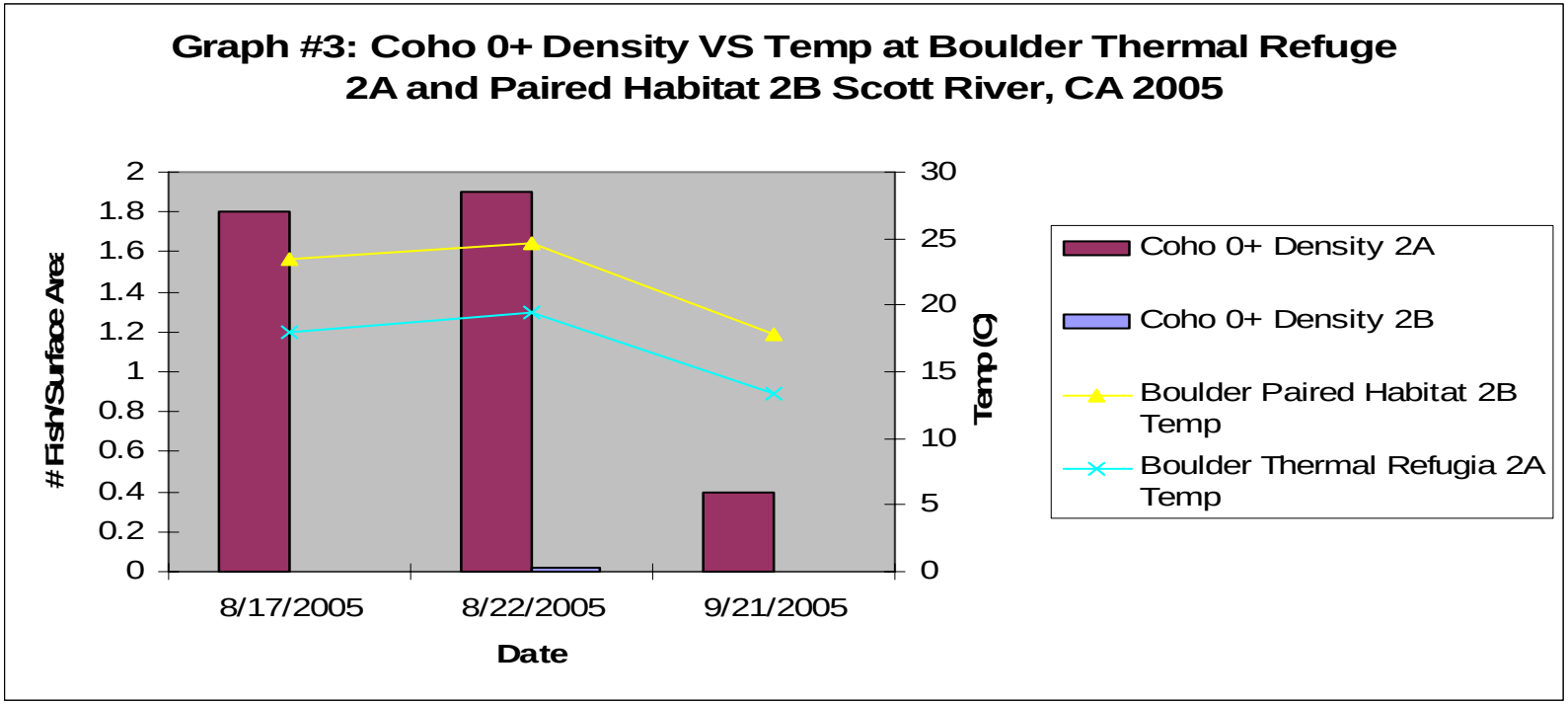
Graph #1: Salmonid density averages VS thermistor readings from the Kelsey Creek thermal refugia 3A and paired habitat 3B. Salmonid densities by age class and species are graphed (Graph #1) for the duration of the dive counts, 7/26/05 through 9/20/05. Coho salmon 0+, rainbow/steelhead trout 0+, rainbow/steelhead trout 1++ and Chinook salmon

0+ densities show notable trends. All four salmonid density trends increase on 08/4/05 as temperatures increase (23.3 ºC) at the paired habitat. Salmonid density peaks on 08/23/05 the temperature at Kelsey 3B was 21.1ºC. The lowest density after the peak was on 09/08/05 corresponding to a temperature decrease (17 ºC) at 3B.



Graph #2: Kelsey paired habitat 3B coho 0+ density VS temperature at Kelsey 3B from 07/26/05 through 09/08/05.

Graph #2 depicts coho 0+ density from 07/26/05 through 09/08/05 at Kelsey paired habitat 3B. Coho 0+ density decreases as temperature increases (23.3 ºC) at the paired habitat, 08/04/05. Density of coho 0+ increases at paired habitat 3B when temperatures decrease (21.1ºC), 08/16/05.



Graph #3: Comparison of coho 0+ densities VS temperatures at Boulder thermal refugia habitat 2A and paired habitat 2B.

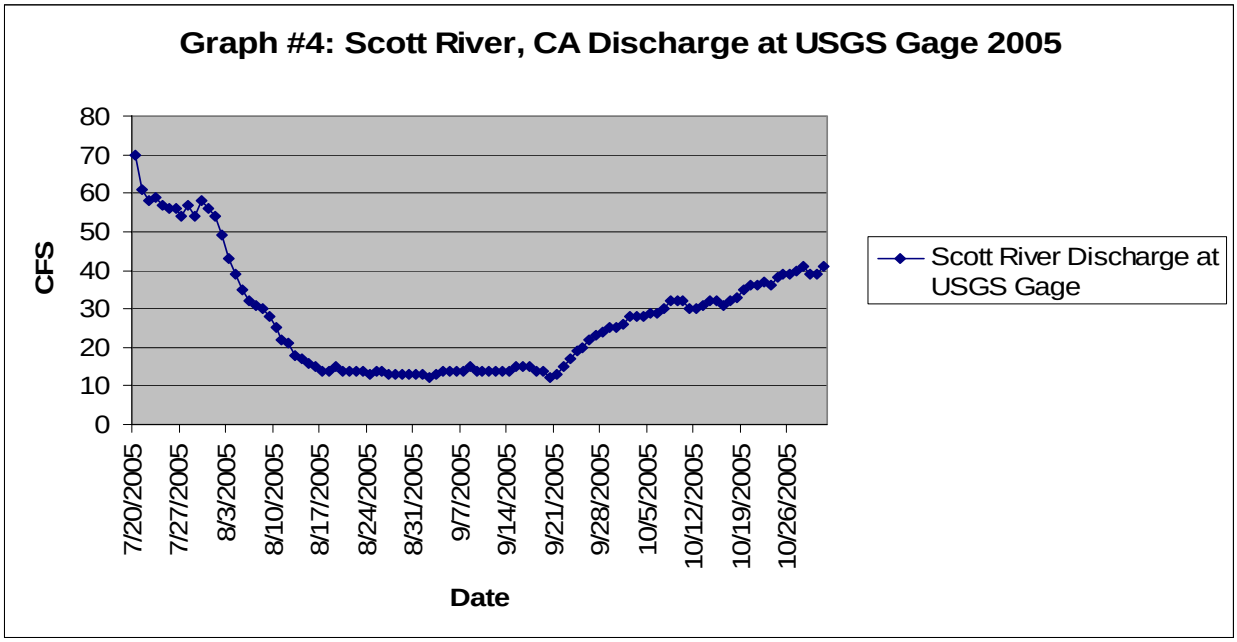
Coho 0+ density at Boulder thermal refuge 2A shows an increase in density on 08/22/05 corresponding to a water temperature increase at 2B (24.6ºC). As water temperature drops at 2B (17.8 ºC) so does coho 0+ density. Coho 0+ density at Boulder 2A compared to Boulder 2B is greater from 08/17/05 through 9/21/05, the duration of diving

C. Discharge

Table #6: Summer Flow Discharges on Scott River, CA Tributaries and Mainstem 2005		
River/Creek	**Date**	**Total Flow (q)**
Scott River @ USGS Gauge	8/18/2005	13.8
Boulder Creek	8/23/2005	3.2
Canyon Creek	8/23/2005	7.7
Kelsey Creek + Channel	8/18/2005	3.6
Deep Creek	8/24/2005	1.5
Middle Creek	8/25/2005	1.4
Tompkins Creek	8/24/2005	1.3
Scott River @ Gold Flat	8/25/2005	39
Scott River @ USGS Gauge	9/22/2005	12.4

Table #6: Scott River, CA tributary and main stem discharges 2005.

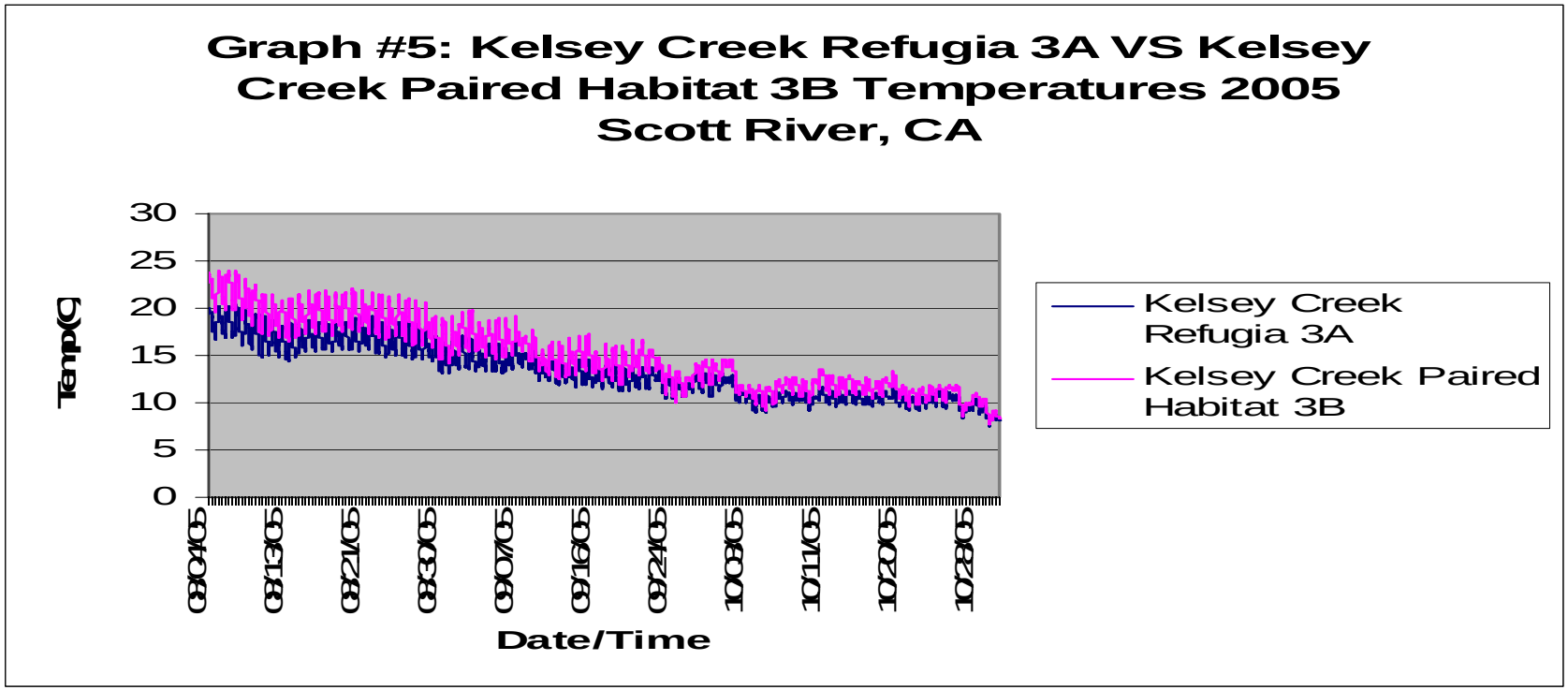
Table #6 lists discharge taken on tributaries and the mainstem Scott River by field crews during the 2005 Thermal Project. The largest cold water tributary on the mainstem Scott below the USGS gage is Canyon Creek. Kelsey Creek is the second largest and Boulder Creek is the third. Tompkins, Middle and Deep Creeks are all contributing about the same cfs to the Scott.



Graph #4: USGS Scott River Flow data near Ft. Jones, CA 7/20/05 through 10/31/05. Graph #4 depicts the Scott River discharge beginning on 7/20/05 and ending 10/31/05. Hydrograph data was downloaded from the USGS web site for the duration of the project. A cfs drop in discharge occurs on August 3rd and continues to decline to August 17th. After this point the discharge remains somewhat steady, varying by a few

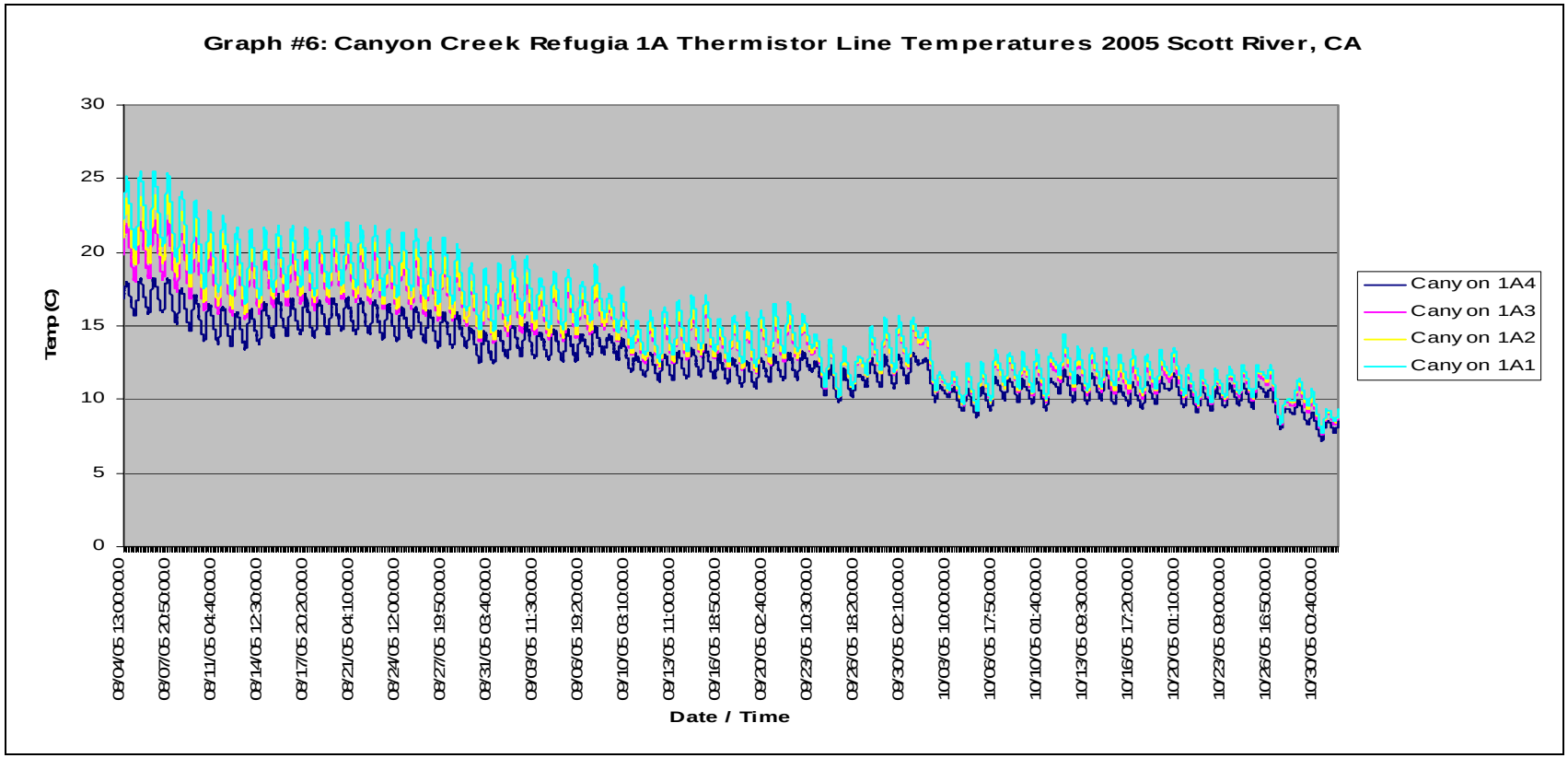
cfs, until September 23rd. The lowest discharge recorded was on September 2nd and September 20th, 12 cfs on each day. Discharge gradually increases beginning on September 22nd, 2005.

Temperature Monitoring

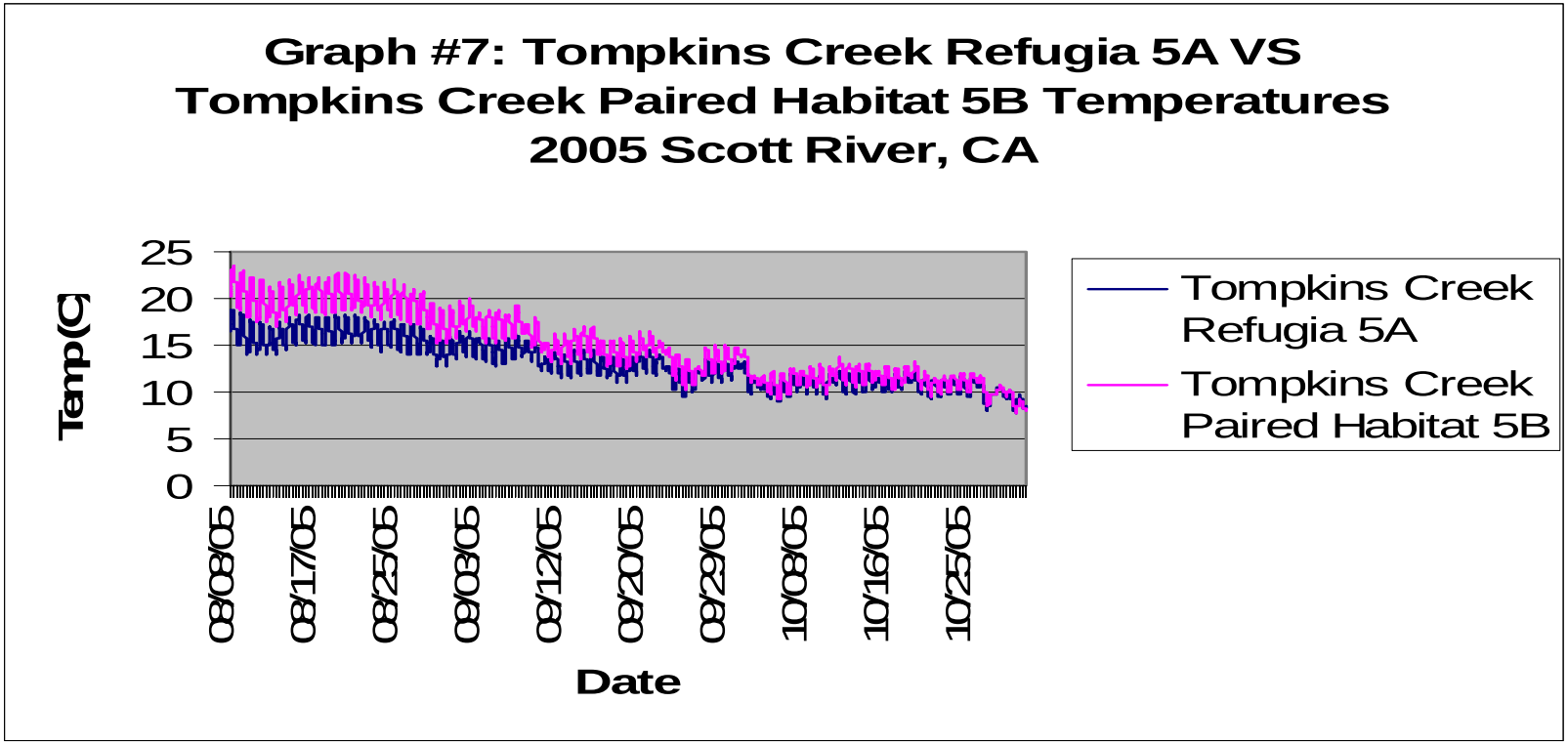


Graph #5: Thermistor temperature reading on Kelsey Creek refugia (3A) and the Kelsey Creek paired habitat (3B).

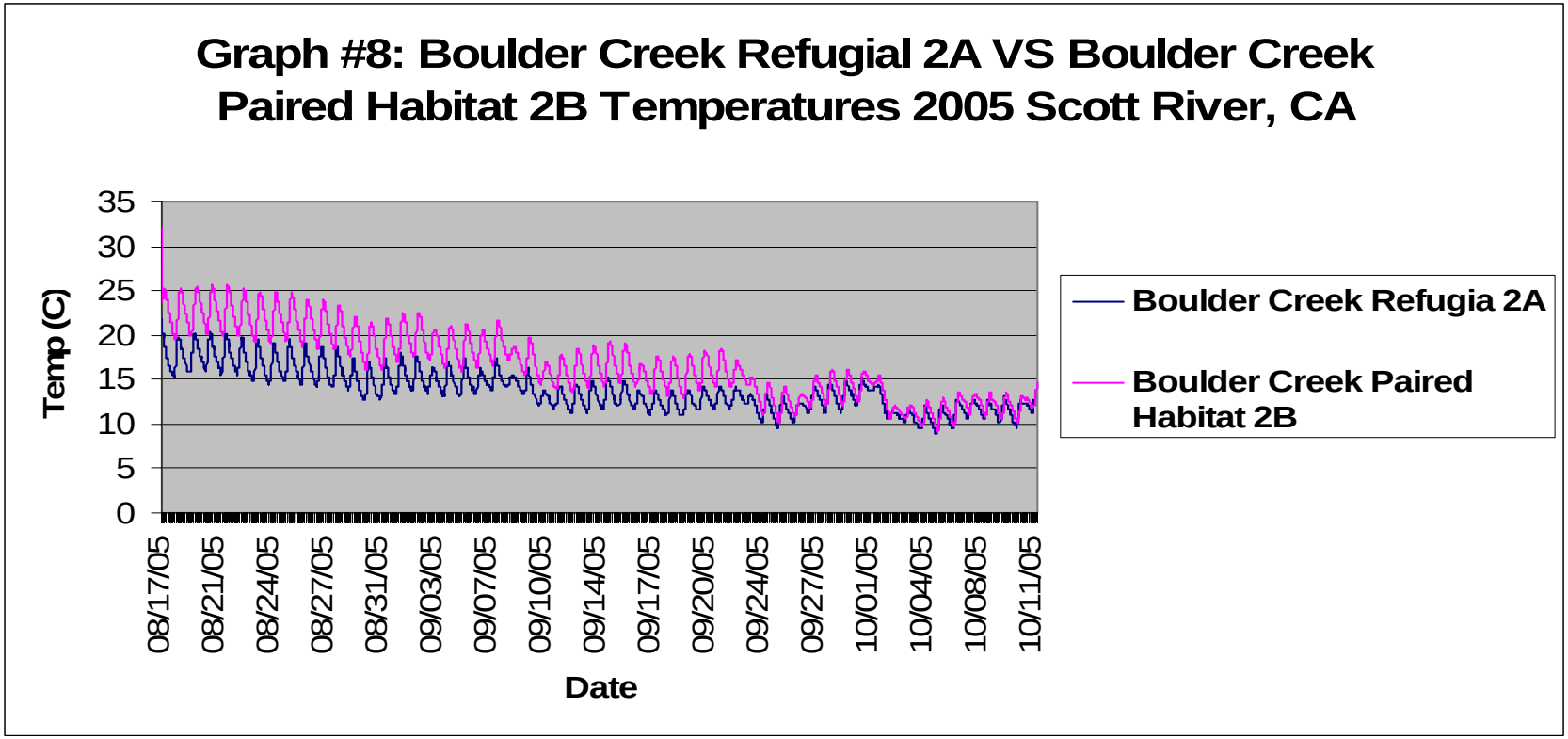
Graph #5 compares thermistor readings taken every ten minutes on the Scott River at Kelsey Creek refugia (3A) and the Kelsey Creek paired habitat (3B). Thermistor readings start on 08/04/05 and end on 10/31/05. Temperature in both 3A and 3B fluctuates diurnally. There is a one to two degree overlap in temperature over a 24 hour period between 3A and 3B for the duration of the project. Temperature differences after 9/24/05 between 3A and 3B are minimal.



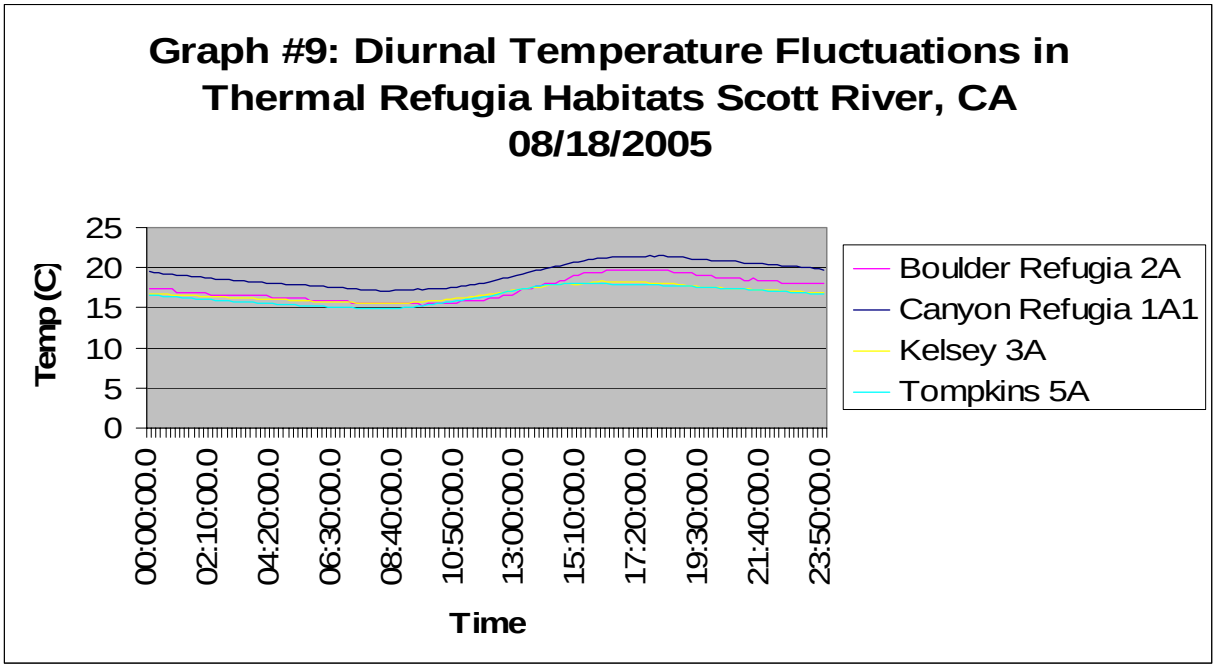
Graph #6: Thermistor string 2005 Canyon Creek refugia (1A). Graph #6 compares Canyon Creek refugia (1A) temperatures, recorded every ten minutes, beginning on 8/04/05 and ending on 10/31/05 on the Scott River. Three thermistors were placed inside the refugia (1A1-1A3) and one thermistor (1A4) was placed in the ambient Scott River mainstem. Thermistor distances from river left, at the mouth of Canyon Creek, are as follows: 1A1=3.3m, 1A2=7.8, 1A3=9.5m and 1A4=12.5m. Temperatures increase from river left to river right. There is no overlap in diurnal temperature fluctuations between the ambient thermistor (1A4) and the core thermal refugia thermistor (1A1). There is overlap in diurnal temperature fluctuations between thermistors 1A1 and 1A2, and between thermistors 1A3 and 1A4. Temperature readings for 1A1-1A4 all begin overlapping after 9/23/05.



Graph #7: Thermistor on Tompkins Creek refugia (5A) vs. the paired habitat for Tompkins Creek (5B). Graph #7 compares thermistor readings taken every ten minutes on the Scott River at Tompkins Creek refugia (5A) and Tompkins Creek paired habitat (5B). Thermistor readings start on 08/04/05 and end on 10/31/05. Temperature readings on 5A and 5B do not overlap until 9/24/05.



Graph #8: Thermistor on Boulder Creek refugia (2A) and the paired habitat thermistor above Boulder Creek (2B). Graph #8 compares thermistor readings taken every ten minutes on the Scott River at Boulder Creek refugia (2A) and the Boulder Creek paired habitat (2B). Thermistor readings start on 08/17/05 and end on 10/11/05. Temperature differences between 2A and 2B are insignificant after 9/24/05.



Graph #9: Temperature fluctuations over a 24 hour period in thermal refugia units on the Scott River, CA 08/18/2005. Water temperatures inside and outside thermal refugia fluctuate diurnally. Graph #9 depicts thermistor readings from four thermal refugia on the Scott River mainstem. Peak temperatures begin at 1630 and flat line until 1830 at all refugia sites with the exception of Tompkins refuge. Tompkins 5A peaks at 1440 and flat lines until a decline at 1830.

Table #7: MWAT Calculations Scott River Mainstem, CA 2005

Thermistor Locations	MWAT	Dates of MWAT	Daily Maximum Temperature Average (during MWAT)
Roxbury Bridge	24.0 ºC	08/03/05 - 08/10/05	27.0 ºC
USGS Gage	20.0 ºC	08/18/05 - 08/24/05	24.2 ºC
Canyon 1A1	19.5 ºC	08/16/05 - 08/22/05	21.7 ºC
Canyon 1A4	15.7 ºC	08/15/05 - 08/21/05	17.0 ºC
Boulder 2A	17.4 ºC	08/18/05 - 08/24/05	19.8 ºC
Boulder 2B	22.4 ºC	08/18/05 - 08/24/05	25.2 ºC
Kelsey 3A	17.0 ºC	08/16/05 - 08/22/05	18.8 ºC
Kelsey 3B	19.2 ºC	08/20/05 - 08/26/05	21.5 ºC
Tompkins 5A	16.6 ºC	08/19/05 - 08/25/05	17.9 ºC
Tompkins 5B	20.6 ºC	08/17/05 - 08/23/05	22.4 ºC

Table #7: MWAT calculations taken from thermistors at USGS gage, Roxbury Bridge, Kelsey 3A and 3B, Boulder 2A and 2B, Canyon 1A1 and 1A4, Tompkins 5A and 5B. Calculated Maximum Weekly Average Temperature (MWAT) values are highest (24ºC) at Roxbury bridge in 2005. The lowest MWAT value was at thermal

refugia habitat Canyon 1A1. Dates of the MWAT varies slightly with each location, all MWAT's are within the weeks of 08/15/05 – 08/26/05 with the exception of Roxbury bridge MWAT (08/03/05 – 08/10/05).

Discussion

A. Investigations

From August 16th to September 22nd, 2005 the Scott River discharge from the valley, taken at the USGS gauge, fluctuated between 12 and 15 cfs (averaging 13.8 cfs). The calculated MWAT values for USGS Gage, Roxbury, thermal refugia sites and paired habitats indicate that the warm valley water entering the canyon is being cooled for a portion of the river by three significantly sized tributaries (Boulder, Canyon, Kelsey) and then begins to equilibrate with the air raising water temperatures before exiting into the Klamath River.

The results of a temperature investigation occurring on 8/17/05 and data taken from long-term monitoring thermistor sites on the Scott River mainstem revealed a continuous portion of the river to be cooler than the rest of the mainstem. This area has been termed a "thermal reach". Temperatures from this investigation are listed in Table #2 and represent temperatures between the hours of 1400-1500 with a Scott River discharge of 14 cfs. MWAT values and maximum temperature averages within the MWAT are calculated in Table # . There is a 5º C temperature difference from the USGS Gage (ºC) to Boulder Creek (ºC) . There is a 3.5º C temperature difference between Townsend river access (ºC) and Roxbury Bridge (ºC). The lowest temperature reading taken at Bridge Flat river access (ºC) was 7.9º C less than the temperature at the USGS gage (ºC) and 4.4º C less than temperature at Roxbury Bridge (ºC). The thermal reach was found to be 5.7 miles in length and extended from Boulder Creek to Townsend river access on 8/17/05.

Comparisons of tributary mouth densities inside and outside of the thermal reach (Table #1) reveal a higher tributary mouth density outside the thermal reach vs. inside the thermal reach. The ambient river temperature inside the thermal reach is lower than the rest of the Scott River. This may be the key environmental factor in the density differences found in 2005. The Kelsey, Canyon and Boulder Creek refugial sites are within the thermal reach. However, Boulder Creek refugia is on the up-river edge of the thermal reach. There is a greater density of coho rearing at Boulder refuge (1.8 fish/m²) compared to Kelsey (0.5 fish/m²)) and Canyon (0.3 fish/m²)) refugia habitats. Unnamed Tributary 8.9 is located on the lower edge of the thermal reach, near the Sugarpine River Access. The density of coho 0+ at this tributary mouth (0.96 fish/m²)) was greater than Kelsey (0.5 fish/m²)) and Canyon (0.3 fish/m²)) refugia as well. All investigated tributary mouths outside the thermal reach exhibit higher densities than inside.

The average density of coho 0+ rearing at seeping cold water points was greater than the average density at tributary mouths. This may indicate a preference for a slower velocity than that offered at tributary mouths. Tributary water entering the Scott creates an increase in velocity at refugial locations and often enters into the thalwag. Cold water seep points create very little velocity difference and are most always located out of the thalwag. One unusual seep investigated in 2005 was found at a bend in the river with the thalwag hitting against the seeping cold water point. There was not a detectable temperature difference located here. The cover at seep locations was also very poor

(<5% boulder and/or terrestrial vegetation) if at all existent. Cover percentages and types are estimated in the raw data for refugial habitats of Kelsey (15% bedrock, boulder, and white water), Canyon (45% boulders and white water) and Boulder (15% boulders and white water).

B. Dives

Statistical analysis was performed for the Kelsey Creek refugia 3A and its paired habitat 3B. A temperature preference for 0+ coho between the Kelsey creek mouth and the paired habitat was not detected in the 2005 dive data. This could be attributed to the overall cooling of the Scott River ambient temperature from Boulder Creek to Townsend river access, 5.7 miles. The paired habitat for Kelsey Creek, used for comparison, was inside the thermal reach indicating that Kelsey thermal refuge 3A may not be as necessary being on the inside of the thermal reach.

Densities for coho, trout and Chinook salmon VS temperatures were analyzed on Kelsey thermal refugia 3A (Graph #1). Kelsey 3B thermistor was used to assess the ambient temperature inside the thermal reach at 1500, the time of the dive. A bi-modal peak is depicted in Graph #1 for coho 0+ densities at Kelsey thermal refugia 3A. Coho 0+ density increases gradually starting on 07/26/05 to a peak density of 0.51 fish/m² on 08/08/05 with a temperature at Kelsey 3B of 22.8º C. Coho 0+ density decreases rapidly on 08/11/05 to 0.25 fish/m², temperature at Kelsey 3B was 21.5º C. Thermistor analysis of Kelsey 3A and 3B indicates a temperature decrease on the Scott River beginning on 08/09/05 through 08/16/05 this corresponds to the decrease calculated for density at Kelsey 3A. The lowest Kelsey 3B temperature was recorded on 08/16/05, 21.1º C. Coho 0+ density increases again on 08/16/05 to a peak density, for the duration of the dives, on 08/23/05 of 0.79 fish/m². Thermistor analysis of Kelsey 3A and 3B show a trend of increasing temperatures after 08/16/05 to a peak on 08/23/05, 21.4º C. However, this is not the highest recorded period of temperatures at Kelsey 3A and 3B. The highest recorded temperatures, at Kelsey 3B, were on 08/03/05 a temperature of 23.3º C. The first coho 0+ density trend peaks with the highest recorded temperature. However, the second coho 0+ density peak is greater than the first and the temperature is lower. This may be attributed to one or all of the following: cumulative effects from water quality stress, CDFG fish rescue efforts, or an overall habitat loss as the summer continues. Coho 0+ density decreases rapidly to 0.01 on 09/08/05, this corresponds to the temperature decrease at Kelsey 3B to 17º C. Similar trends are apparent for rainbow/steelhead trout 1++ and Chinook 0+ at Kelsey thermal refugia 3A. Rainbow/steelhead trout 0+ do not show a peak density occurring at 08/08/05, but does show a peak density (0.42 fish/m²) occurring on 08/23/05.

Densities for coho 0+ VS temperature were analyzed for Kelsey 3B in Graph #2. Coho 0+ density decreases as temperatures inside the thermal reach increase. The density decreased to 0.008 fish/m² on 08/04/05 when the temperature in Kelsey 3B increased to 23.3ºC. The greatest density (0.12 fish/m²) of coho 0+ occurred in paired habitat 3B on 08/16/05, temperature dropped to 21.1ºC. Thermistor analysis of Kelsey 3B indicates a temperature decrease occurring from 08/09/05 – 08/16/05.

Canyon Creek refugia 1A and its paired habitat 1B were dove twice during the course of the 2005 project. Statistical analysis was not possible for fish counts at either site. However, it is notable that the paired habitat 1B had an average coho 0+ density of

0.16 fish/m². The refugia habitat 1A had an average coho 0+ density of 0.28 fish/m². The paired habitat for 1B is inside the thermal reach. Sites 1A and 1B experienced some level of influence from CDFG fish rescue projects.

Boulder Creek refugia 2A and its paired habitat 2B were dove three times in 2005. Statistical analysis was not possible for this site in 2005. However, the paired habitat for Boulder Creek is outside the thermal reach and the refugia habitat is on the upper-most edge of the thermal reach. The density of coho 0+ in the Boulder Creek refugia 2A was greater than its paired habitat 2B, Graph #2. Density trends follow temperature trends, as temperature increases so does the coho 0+ density and vice versa. It is important to note the last dive on 9/20/05 observed 45 coho 0+ holding in the stratified pool at 2A. Thermistor analysis on 9/20/05 at 1530 for the stratified pool (13.4º C) and the paired habitat (17.8º C) shows a difference of 4.4º C between the two sites during the dive. Temperature differences between Boulder 2A and 2B become non-existent after 09/24/05 based on thermistor analysis.

Three dives occurred on Pat Ford thermal refugia 7A and its paired habitat 7B in 2005. Statistical analysis was not possible on this site. Fish counts on 08/08/05 and 08/24/05 indicate that a depth preference for coho 0+ may exist in certain refugial habitats. On 08/24/05 it was noted that the refugia habitat surface area increased however, the depth dropped to about six inches decreasing the volume. The decrease in depth corresponded to a decrease in cover for the Pat Ford refugia (7A). Fish counts on 08/08/05 observed 18 coho 0+ utilizing the Pat Ford refugia habitat, depth was twelve inches. One coho 0+ was observed on 08/24/05 utilizing the shallow habitat. The Scott River discharge on 08/08/05 was 30 cfs and on 08/24/05 the discharge was 13 cfs. The depth needed by coho 0+ salmon has not been empirically defined and differs based on each locations fish species, sizes, types/amounts of cover and the size of the stream (Meehan, 1991).

**Discussion section has not been updated to reflect paired t-test analysis conducted by Bret Harvey, Redwood Sciences Lab. His analysis shows a significant difference (level of significance = 0.05) between fish densities within and outside of cold water habitats when ambient water temperatures are above 22°C. This differs from my analysis that compared fish densities of within and outside cold water habitats at all ambient water temperatures. Consequently, preference for cold water habitats appears to be most noticeable at temperatures at or above 22°C –R.Quiñones, Klamath National Forest 7/18/07

C. Discharge

The Scott River discharge at the USGS gage on the 18th was 13.8 cfs and at Gold Flat river access was 39 cfs, Table #6. An additional 25.2 cfs enters the Scott between the USGS gage and Gold Flat. Discharges taken on the following tributaries account for 18.7 cfs: Boulder, Canyon, Kelsey (+ channel), Deep, Middle and Tompkins Creeks. Six and a half cfs is unaccounted for; this may be a combination of: intermittent/perennial streams, seeps and upwelling. This much inflow characterizes the 2005 water year type, limited valley input (~14 cfs), and was able to significantly cool a 5.7 mile stretch of the Scott River (Boulder Creek to Townsend).

D. Temperature Monitoring

Statistical analysis occurred for fish counts on Kelsey 3A and 3B habitats. Overlapping values indicate that no temperature preference by coho, Chinook salmon and steelhead trout is occurring between these two sites. The overlapping temperature values may account for this. The maximum temperature inside the thermal reach at Kelsey 3B on 08/07/05 at 1630 was 24º C. The ambient river temperature taken from the Jones Beach thermistor on 08/07/05 at 1630 was 26.8º C. The ambient river temperature taken from the Roxbury Bridge thermistor was 27.5º C on 08/07/05 at 1600. The Kelsey 3B site (24º C) was to represent the ambient river temperatures but, was found through thermistor analysis and MWAT values to be a thermal refuge from the ambient river temperatures taken at Jones Beach (26.8º C) and at Roxbury Bridge (27.5º C).

Boulder Creek thermal refugia 2A and paired habitat 2B thermistor comparison illustrates the Scott River ambient outside the thermal reach vs. the Boulder Creek stratified pool temperature. Diurnal fluctuations in temperature occurred at each site without overlap between the sites. The maximum temperature at Boulder 2B was 25.6º C on 08/21/05 at 1640. The maximum temperature at Boulder 2A on 08/21/05 at 1640 was 20.1º C. Graph #2 illustrates the highest coho 0+ density at Boulder 2A occurring on 08/22/05 with an ambient temperature (Boulder 2B) of 24.6º C at the time of the dive. Temperature preferences for coho salmon were observed at this location but without statistical validity.

Thermistor and fish count analysis indicates that Boulder 2A, 2B and Tompkins 5A, 5B may be better locations for proving or disproving coho 0+ temperature preferences on the Scott River. Temperatures in both refugia habitats versus both paired habitats have a difference of 5º C from each other for the majority of the project. Boulder 2B is located outside the thermal reach however, Tompkins 5B is not and would need to be relocated.

Peak temperatures on the Scott River mainstem begin at 1630 and remain steady until 1830, Graph #6. This is consistent between Kelsey, Canyon and Boulder refugia units. Tompkins thermal refugia (5A) reaches peak temperature two hours earlier but declines at the same time as the other sites. Tompkins refugia is the furthest downstream and may be equilibrating water and air temperature at a faster rate than tributaries upstream.

E. Overall Integrated Summary

The overall standing crop of coho 0+ salmon inside thermal refugia (578.8 m^2 total refugia habitat) in 2005 on the Scott River mainstem canyon was 895 coho 0+. The average density of coho 0+ using thermal refugia habitat in 2005 in the canyon was 1.5 fish/m^2. Our greatest coho 0+ density was found at seeps when compared to other types of thermal refugia.

No statistical difference was found inside the thermal reach for temperature preference by juvenile coho 0+ for Kelsey thermal refugia habitat 3A VS Kelsey paired habitat 3B. The ambient river temperature inside the thermal reach did not exceed 23.9º C in 2005. Unfortunately, the same analysis was not possible, in 2005, for a comparison outside the thermal reach to be made where ambient river temperatures were higher.

Refugia habitat inside the thermal reach may be at times less important than refugia habitat outside the thermal reach to stressed salmonids.

Based on Kelsey 3A densities for coho 0+, steelhead/rainbow trout 0+ and 1++ and Chinook 0+, refugia habitat seems most important inside the thermal reach from 08/02/05 through 8/31/05. Analysis of Kelsey paired habitat 3B indicates that the thermal reach habitat is somewhat suitable until temperatures inside the thermal reach exceed 22ºC. The importance of refugia habitat for the steelhead/rainbow 1++ may be connected to the food source (0+ fish) being forced into thermal refugial habitats rather than a temperature preference. Field notes indicate larger steelhead/rainbow trout 1++ often on the edge or just outside of the thermal refugia habitat while 0+ salmonids and rainbow/steelhead trout are inside the cold water refugia.

Boulder refugia 2A, although not done to statistical validity, indicates refugia habitat on the edge on the thermal reach may be important through 09/20/05.

The greatest density of coho 0+ using Kelsey thermal refugia 3A occurred on 08/23/05 with a thermal reach temperature of 21.4º C. The greatest density of coho 0+ using Boulder 2A occurred on 08/22/05 with ambient river temperatures of 24.6º C. Kelsey 3A had temperatures greater than the temperature on 08/23/05 but with coho 0+ densities lower than densities on 08/23/05. Multiple factors may be connected to this. As the summer progresses suitable habitat decreases maybe causing more coho 0+ to seek thermal refuge. Cumulative water quality stress may cause a greater need for refugia later in the summer. However, California Department of Fish and Game juvenile fish rescue efforts may be masking the true coho 0+ densities in relationship to temperature. Juvenile release locations in 2005 were on Canyon Creek below the bridge and on the mainstem Scott River at Shackleford Creek. Both release locations are above Kelsey Creek refugia 3A, one release location is above Boulder refugia 2A. However, coho 0+ density was higher at Boulder refugia 2A than Kelsey refugia 3A. This may be due to releasing rescued fish inside the thermal reach (Canyon Creek) versus outside (Scott River @ Shackleford). In efforts of juvenile salmonid rescue, the release location of Canyon Creek may be a better location than Scott River at Shackleford for these already stressed fish.

Suggestions for 2006

A. Dives

Determine, based on flow, the sites to be monitored with intense diving. Understand which questions you want to answer. Boulder refuge and the Unnamed Tributary 8.9, above the Sugar Pine river access, are more ideal locations for proving or disproving a temperature preference for coho 0+. These two sites, at a similar summer flow regime to 2005 (~14 cfs), are located on the upper and lower bracket of the thermal reach.

Dive above and below USGS gage as close as possible (same day) to a CDFG juvenile fish rescue release day on the Scott River at Shackleford.

Set up thermal habitats without extra non-thermal habitats, this will make comparisons easier.

B. Investigations

Investigate the lower bracket of the thermal reach (Townsend river access ’05). This will be different under differing flow regimes. The upper bracket should also be investigated; in ’05 Boulder Creek was the top of the thermal reach. Boulder Creek under different flow regimes may have less influence possibly causing the thermal reach to not begin until Canyon Creek.

Establish thermal sites and paired habitats outside the thermal reach: photo, hobo, flag, delineate and measure. Or pick multiple habitat pairs to compare to the thermal stretch of refuge (Boulder to Townsend). Based on habitat characteristics, the thermal reach could possibly be compared to a stretch of river between Townsend river access and George Allen Gulch.

C. Discharge

Take discharge of Kelsey, Canyon, Boulder, Tompkins, Middle, Deep and main stem Scott above (USGS Gage ‘05) and below this thermal reach (Gold Flat ’05). Discharge on any other tributary flow site being studied should also be taken. (Trib 8.9, Pat Ford, seeps etc.)

D. Temperature Monitoring

Monitor temperature at the mouth of the Scott River for a comparison of the water temperature leaving the Scott entering into the Klamath River.

Install thermistors earlier in the summer, early June, so that the temperature data does not start in the middle of a peak.

Set up thermistors in as many “key” locations as possible to monitor the thermal reach on a hourly, daily, weekly, flow dependant basis.