Shasta River Juvenile Coho Habitat & Migration Study

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1.0 Abstract

Initial surveys of the upper Shasta River between river miles (RMs) 33.72 and 31.98 in April of 2008 determined that 0+ juvenile coho salmon (*Oncorhynchus kisutch)* were rearing throughout the area surveyed. Age 0+ coho salmon were captured at RM 32 and tagged with passive integrated transponder (PIT) tags in order to study migration behavior and estimate the probability of survival.

A rapid increase in the maximum daily water temperatures from 21.4 degrees C in late April to over 24.2 degrees C during four consecutive days in May displaced juvenile coho from three of the four study sites between RMs 32.9 and 33.6. Some of the PIT tagged juvenile coho responded to the increase in water temperature by migrating over 4 miles upstream to areas of cold spring inflow. All observed over-summer rearing habitat utilized by coho was associated with cold springs.

Throughout the summer of 2008, coho reared successfully at three study sites on the Shasta River mainstem between RMs 36 and 36.8, where the weekly maximum temperatures ranged from 20.57 to 22.47° C. Juvenile coho were also observed rearing during the summer in Kettle Springs Creek at the outfall of Kettle Springs, in Big Springs Creek at the outfall of Big Springs Lake and at a small coldwater seep on the mainstem Shasta River at RM 33.3.
Summer rearing habitat downstream of the cold spring at RM 37 on the Shasta River was impacted by water use practices including the release of warm stored water from an upstream reservoir, diversion of spring water, and warm tailwater returning to the stream.

We used a Cormack-Jolly-Seber live-recapture model (Schwarz and Seber 1999) in program MARK (White and Burnham 1999) to obtain maximum likelihood estimates of apparent survival (Φ_i) and recapture probability (p_i) over three river segments for coho smolts emigrating from rearing habitats on the Hole in the Ground (HIG) Ranch in the spring of 2009 (3/15/09 to 5/30/09). Estimates of apparent survival for coho smolts emigrating from the principal rearing habitat on the Shasta River (RM 36.0 to 36.8) were made using PIT tagged coho and remote detection systems located at key points through out the watershed. These estimates of survival identified specific stream reaches in the Shasta River where survival was reduced.

Recommended changes to management practices include conservation of spring water and the elimination of tailwater return to cold water refugial areas

2.0 Background

Declining numbers of coho salmon in the Southern Oregon/Northern California Coast Evolutionary Significant Unit (SONCC ESU) have led to the listing of coho salmon (*Oncorhynchus kisutch)* as threatened under the Endangered Species Act (ESA) and the California Endangered Species Act (CESA). These listings have resulted in increased monitoring of coho populations in key watersheds including the Shasta River.

Since 2001, the California Department of Fish and Game (CDFG) has counted the number of coho returning to spawn in the Shasta River and estimated the number of smolts produced by these fish (Chesney D. 2008; Chesney W. et al. 2009). Table 1 shows the number of smolts produced per returning adult from Brood Years 2001 – 2006. Table 2 shows the number of adults returning per smolts produced and the smolt-to-adult survival for Brood Years 2004 through 2008. Using the average number of smolts produced per adult; we have projected the number of smolts we expect to be produced in 2009 and 2010. Table 2 shows the projected adult returns for 2009 – 2011 using the average smolt to adult survival rate of 2.9%. The number of smolts produced per adult has ranged from 38 smolts per adult in 2003 to 4.4 in 2008. A downward trend is shown for all three cohorts (Figures 1-3).

Table 1. Coho 1+ produced per returning adult

Brood Year	Adults	1+ produced in	Year	smolts per adult
2001	291	11,052	2003	38.0
2002	86	1,799	2004	20.9
2003	187	2,054	2005	11.0
2004	373	10,833	2006	29.0
2005	69	1,178	2007	17.1
2006	47	208	2008	4.4
2007	255	***5118***	***2009***	***20.1***
2008	31	***622***	***2010***	***20.1***

Projected production in 2009 and 2010 based on average production of 20.1 1+ per adult observed for brood years 2001 - 2006

Table 2. Coho 1+ to adult survival

Brood Year	**Adults**	**Emigration year**	**1+ produced**	**% return**	**Adults returning in**	**Brood Year**
2001	291	2003	11,052	3.37%	373	2004
2002	86	2004	1,799	3.84%	69	2005
2003	187	2005	2,054	2.29%	47	2006
2004	373	2006	10,833	2.35%	255	2007
2005	69	2007	1,178	2.63%	31	2008
2006	47	2008	208	***2.90%***	***6***	***2009***
2007	255	2009	***5,118***	***2.90%***	***148***	***2010***
2008	31	2010	***622***	***2.90%***	***18***	***2011***

Projected 1+ estimates for 2009 and 2010 were made using the mean smolt per adult value (23.2) from 2001 through 2008. Projected adult returns in 2009 - 2011 are based on the average1+ smolt to adult survival rate for 2004 - 2008 (2.90%).

Need for Upper Basin Studies

Estimates of the number of smolts produced per adult have allowed us to identify a variable survival rate for juvenile coho and a projected downward trend in the population. To identify the responsible factors, we needed an understanding of the early life history of coho in the Shasta River and information regarding the location and condition of preferred spawning and rearing habitat. Until recently, restricted access to private land in the Shasta Valley has limited our ability to conduct this initial assessment.

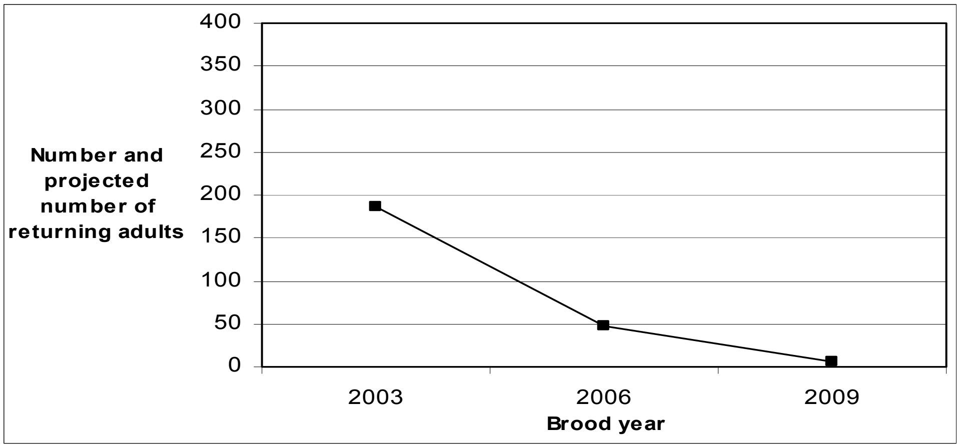


Figure 1. Estimated and projected number of returning Shasta River Coho Cohort A 2003-2009

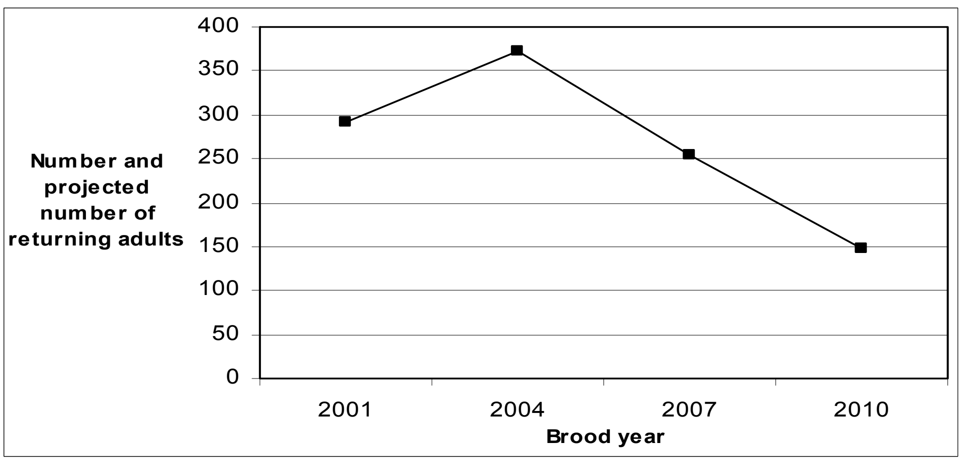


Figure 2. Estimated and projected number of returning Shasta River Coho Cohort B 2001-2010

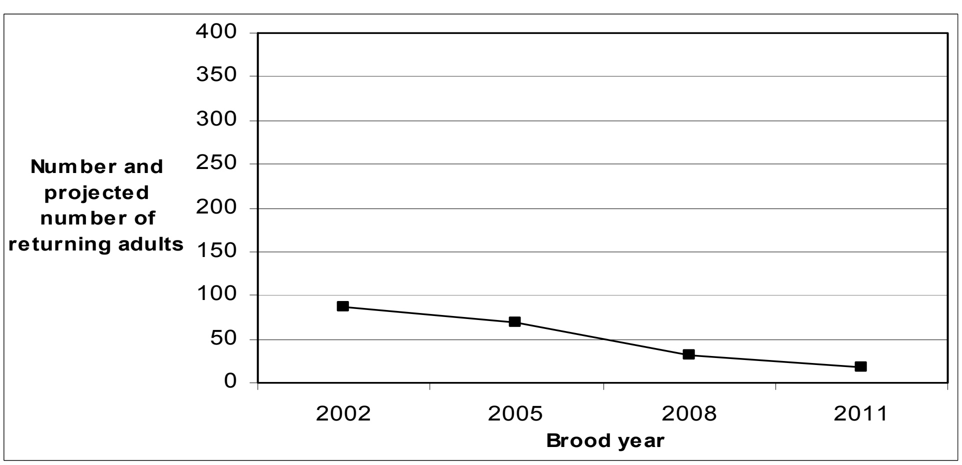


Figure 3. Estimated and projected number of returning Shasta River Coho Cohort C 2002-2011

Location of Spawning Habitat

Radio tagging studies in 2004 through 2009 have determined that the lower six miles of the Shasta River canyon and the upstream area known as the Big Springs Complex shown in Figure 4 are the primary spawning areas for coho in the Shasta River (Littleton and Pisano, 2006; Olswang, 2007, and 2008).

Juvenile Rearing Habitat in the lower Shasta River

Rotary trapping at the mouth of the Shasta River has documented the emigration of coho fry or parr in response to low flows and high water temperatures which occur after the start of the irrigation season (Chesney et al. 2003). Irrigation is allowed from April 1st through October 1st each year. Maximum daily water temperatures in the canyon during the summer can exceed 30° C. The maximum weekly maximum temperature (MWMT) at the rotary trap site (RM 0.3) during the summer of 2009 was 29.14° C. Due to high water temperatures, low flows and suspected barriers to juvenile migration out of the canyon, we believe the progeny of coho spawning in the Shasta River canyon are unable to find over-summer rearing habitat in the Shasta River.

Juvenile Rearing Habitat in the Big Springs Complex

Historic accounts of 125 cubic feet per second (cfs) of 52° F water from Big Springs (Wales 1952) led us to believe that considerable over-summer rearing habitat should exist in the Big Springs Complex. Based on these accounts, we suspected that progeny of the coho spawning in the Big Springs Complex were finding over-summer rearing habitat in the upper watershed.

In 2006, the Nature Conservancy purchased the Nelson Ranch and allowed CDFG access to the upper Shasta River (RM 27.21 to 32.06). During the spring of 2006 we observed changes in water and diurnal temperatures uncharacteristic of a spring-fed river. No juvenile coho were observed rearing on the Nelson Ranch after May 2006 when water temperatures reached over 24° C (Jeffres 2008). Results of the Thermal Infrared (TIR) surveys conducted for the North Coast Regional Water Quality Control Board (NCRWQCB) in 2003 confirmed that, due in part to tailwater returns, Big Springs Creek was contributing warm water to the Shasta River and that the Shasta River and Parks Creek upstream of Big Springs Creek were also sources of warm water. The TIR data also indicated the existence of cold water springs upstream of Big Springs Creek at RM 37.9, 38.87 and at 39.36. While installing a diversion screen in October 2007, at RM 36.52, CDFG staff observed coho parr and confirmed that over-summer rearing was occurring in the upper Shasta River (Olswang, 2007 field note).

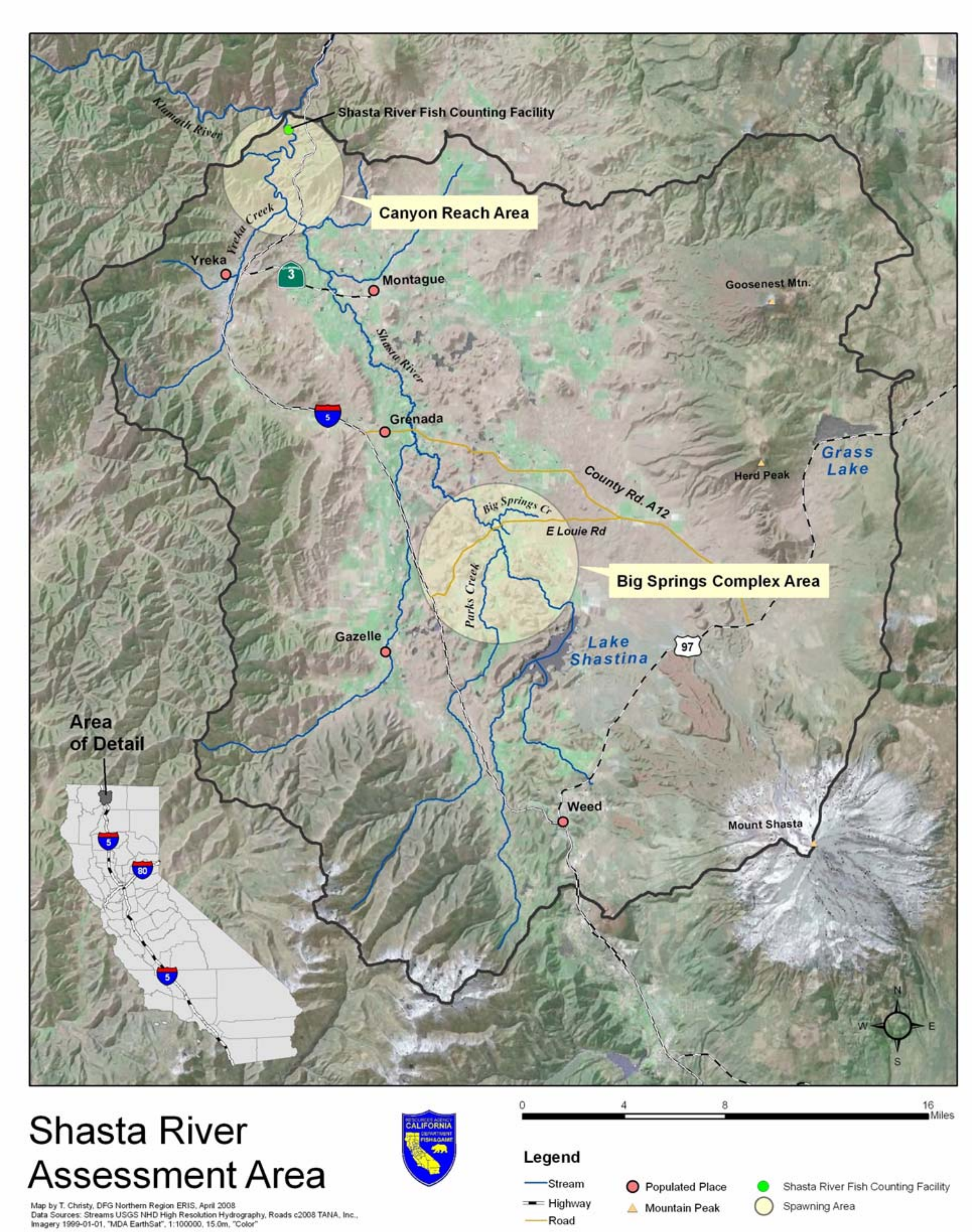


Figure 4. Principal spawning areas for Shasta River coho based on 2004 - 2008 radio telemetry studies

2.1 Study Objectives

The objectives of the study initiated in 2007 were:

1) To determine the location and thermal characteristics of over-summer rearing habitat utilized by juvenile coho within the Big Springs complex.
2) To estimate the probability of survival of juvenile coho salmon rearing and emigrating from the Shasta River.

This study was proposed to work with Cohort B from Brood Year 2007, when the greatest numbers of juvenile coho were likely to be rearing in the Shasta River.

Access to the Big Springs Complex

In February 2008, the study site for this project was limited to the portion of the river passing through the Nelson Ranch. On 3/1/08, the Nature Conservancy purchased an option to buy the Busk Ranch; this option included a one year access to the 4000+ acre ranch including Big Springs Creek and 2.9 miles of the mainstem Shasta River (RM 31.98 to 34.88). The Nature Conservancy granted us permission to include this property in our study. In May 2008, Emmerson Investments Inc (EII) allowed us limited access to the Hole in the Ground (HIG), Shasta Springs and Seldom Seen Ranches. With the addition of these properties; we had access to most of the Big Springs Complex (Figure 5).

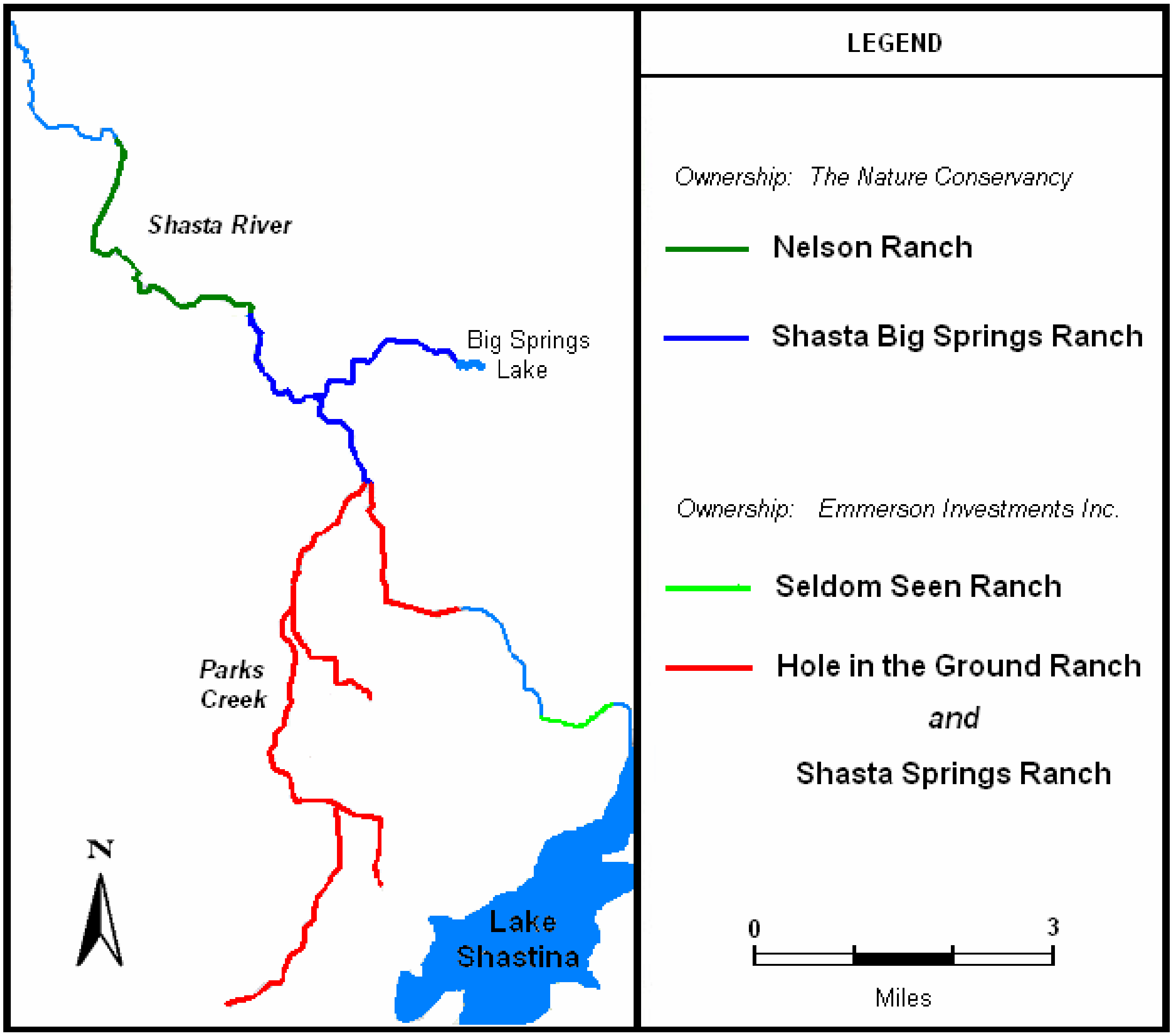


Figure 5. Private ranch ownerships within the Big Springs Complex.

<u>Initial Surveys</u>
Initial reconnaissance level surveys began on 3/20/08 at the Shasta Big Springs Ranch. Our immediate goals were to identify where coho were rearing and establish study sites, capture and implant PIT tags into coho with a fork length over 55 mm and construct tag detection stations. On 5/6/08 we began similar surveys on EII property.

3.0 Methods

To get an understanding of where coho reared during the spring and summer months in the Shasta River and to describe the temperature characteristics of the habitat during this period, we monitored stream temperatures, measured stream flow, conducted snorkel surveys and monitored the location, movement and survival of PIT tagged coho. We monitored juvenile coho rearing habitat on the mainstem Shasta River between RM 32.9 and RM 37.4 (Table 3) at the locations shown in Figures 6 and 7.

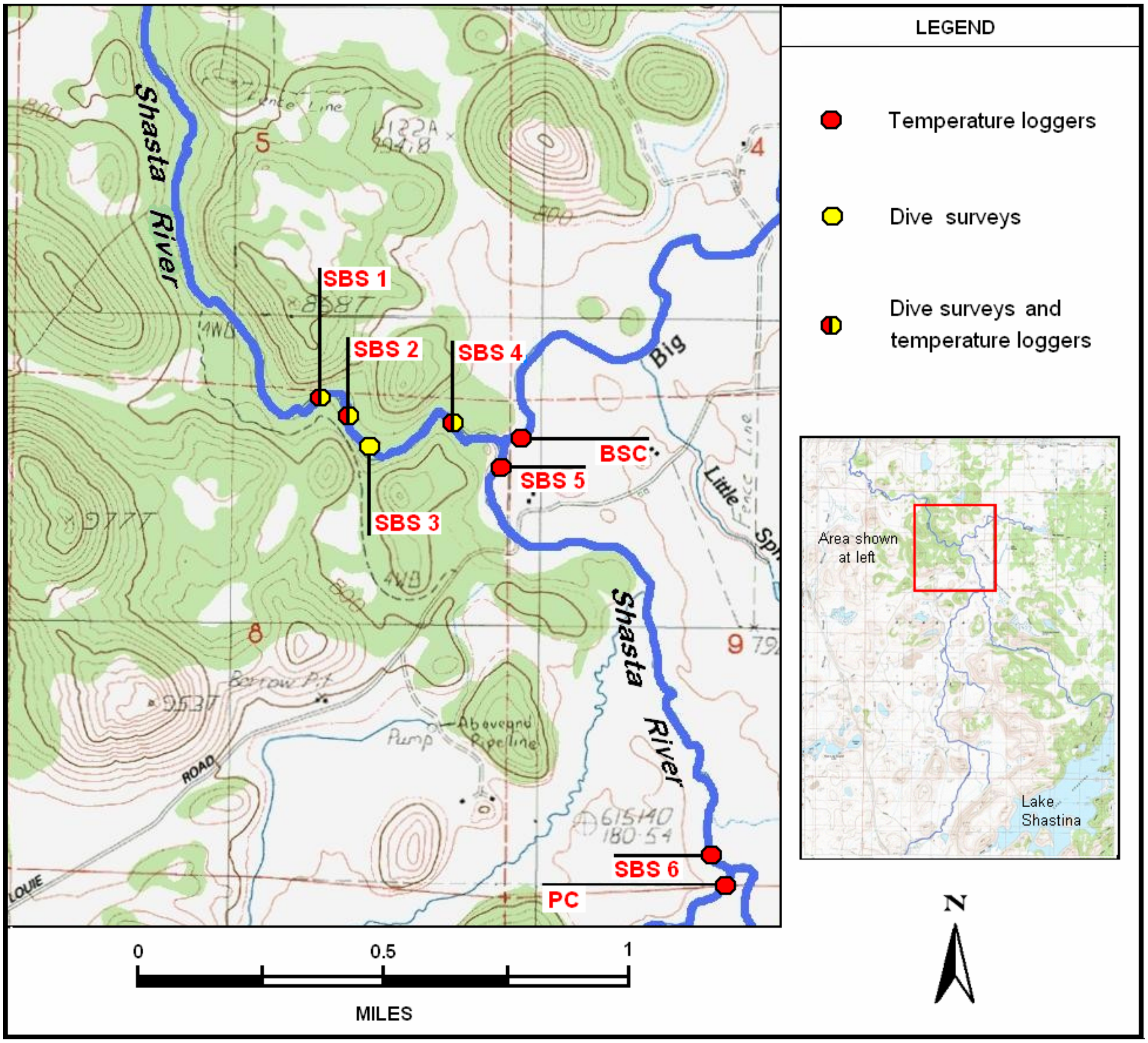


Figure 6. Location of monitoring sites in the upper Shasta River basin at Shasta Big Springs Ranch in the summer of 2008

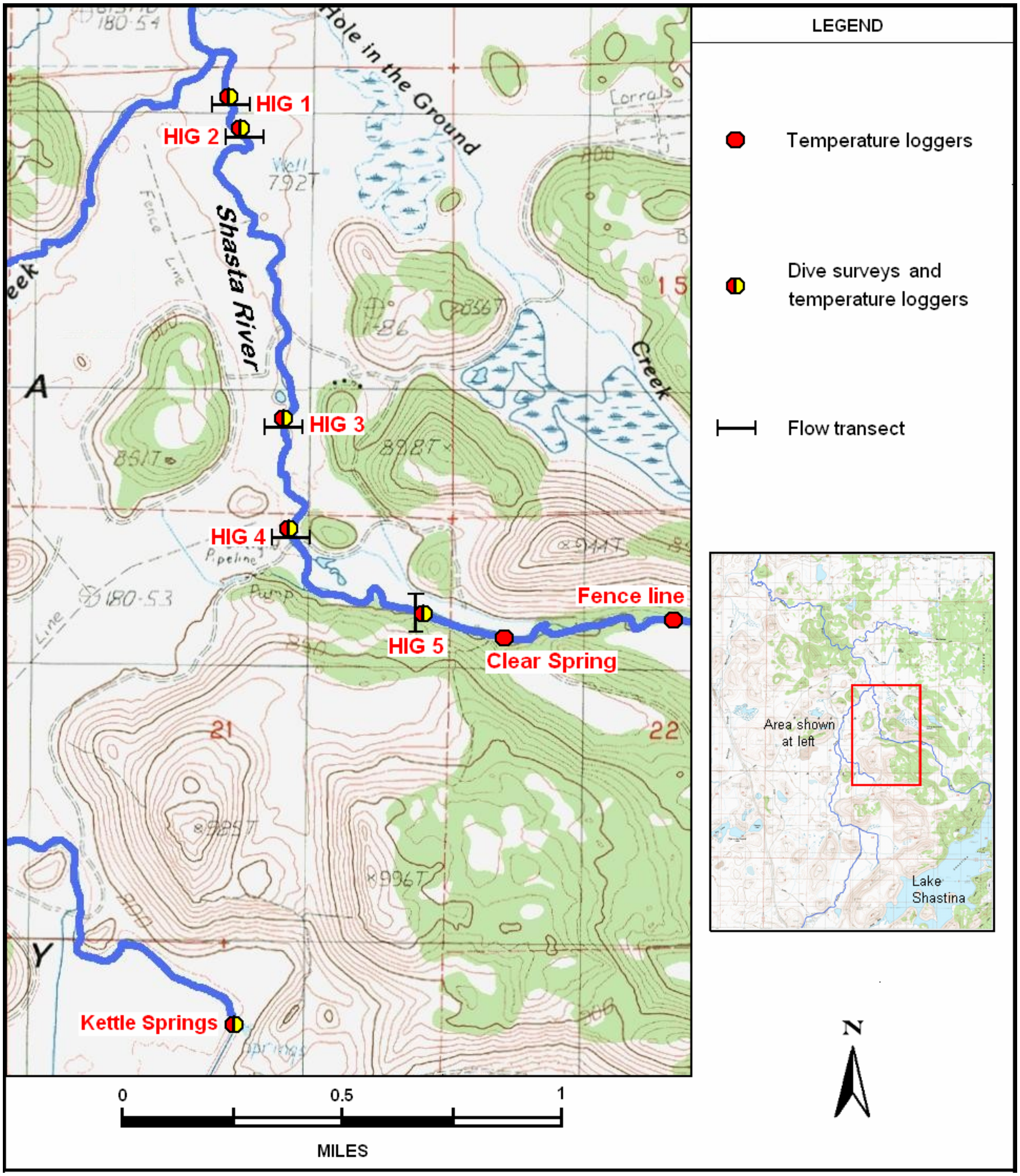


Figure 7. Location of monitoring sites in the upper Shasta River basin at Hole in the Ground and Shasta Springs Ranch in the summer of 2008.

Table 3. Monitoring site names on the Shasta River, Parks Creek and their tributaries.

Site Name	Site Name Abbreviated	River Mile
Shasta Big Springs 1	SBS 1	32.9
Shasta Big Springs 2	SBS 2	33.3
Shasta Big Springs 3	SBS 3	33.4
Shasta Big Springs 4	SBS 4	33.6
Big Springs Creek	BSC	-----
Shasta Big Springs 5	SBS 5	33.7
Shasta Big Springs 6	SBS 6	34.9
Parks Creek	PC	-----
Hole in the Ground 1	HIG 1	35.0
Hole in the Ground 2	HIG 2	35.2
Hole in the Ground 3	HIG 3	36.0
Hole in the Ground 4	HIG 4	36.3
Hole in the Ground 5	HIG 5	36.8
Clear Springs	CS	37.0
Fence Line	Fence	37.4
Kettle Springs	KS	-----

River Mile determined from 2003 TIR survey data (Watershed Sciences, 2004)

3.1 Water Temperature Monitoring Methods

Site Selection of Water Temperature Monitoring Sites
Water temperature loggers were placed at seven sites on the Busk Ranch and eight locations at Hole in the Ground Ranch. Of the total 15 locations, 8 of these logger deployments corresponded to dive site locations where juvenile coho had been found rearing in the summer of 2008. Additional loggers were placed at two spring sources, Kettle and Clear Springs, and also at the mouths of Parks Creek and Big Springs Creek. For added resolution, additional loggers were placed to bracket the river and give a better idea of thermal changes occurring throughout time and location. The river mile and GPS coordinates of the locations where loggers were deployed are shown in Appendix 1. At the request of the EII management, two loggers were placed at each HIG site, with the exception of Clear Springs for the period of record. A second logger was eventually placed at the Clear Springs site.

A total of 23 HOBO U22 Water temp pro v2 loggers (Onset Corp. Part # U22-001) were fielded at several sites in the study area. The loggers are factory calibrated and are accurate within 0.2° C over a 0° to 50° C range. All loggers were set to record temperatures at hourly intervals. For field deployments, individual loggers are placed in an open-ended steel can attached to an anchor point on the bank via stainless steel cable. These assemblies are placed on the bottom, typically near the center of the river in flowing water.

Once in place, logger assemblies were regularly cleaned of debris. Loggers were offloaded in the field through the use of an optical interface communications waterproof shuttle (Onset Corp. Part # U-DTW-1). The shuttle has nonvolatile storage for the preservation of up to 63 logger readouts. The raw data points are offloaded into HOBOware Pro software and then further processed in Microsoft Excel.

Daily and weekly minima, maxima and averages were generated for each location for the period of 4/1/08 to 8/19/08. Additionally, maximum weekly maximum temperatures (MWMT) and maximum weekly average temperatures (MWAT) were established for each river location (Table 5). Box and whisker plots were created for each site per month (Appendix 6). These plots organize data points by hour and allow diurnal changes and variability to be visualized. If a monitoring site contained two loggers, as is the case for HIG locations, box plots were created using the combined data from both loggers. These are standard box plots, with whiskers representing maxima and minima of all data for a particular hour. The boxes bracket the 25th and 75th percentiles.

3.2 Flow measurements Methods

Hole in the Ground Ranch

Streamflow was measured throughout the monitoring period at the five locations on the Hole in the Ground Ranch shown in Figure 2 and in Appendix 1. Water velocities were measured with a Marsh-McBirney Model 2000 flow meter and a top setting wading rod. Velocities were measured and discharge calculated using the methods described by Bovee and Milhous (1978). Suitable transects were located at or as close as possible to the study sites.

Shasta Big Springs Ranch

Streamflow for the Shasta River on the Shasta Big Springs Ranch was measured by the Center for Watershed Sciences (Mount et al. 2009). Stream gauges were installed and rated in the Shasta River, Parks Creek, Hole in the Ground Creek and Big Springs Creek. Total flow downstream of Big Springs Creek was determined by adding the flow from the individual streamflow gauging stations.

3.3 Direct Observation Methods

We used direct observation techniques to monitor salmonids rearing in selected study sites. The purpose of these dives was to determine the presence/absence of juvenile salmonids rearing at study sites under different stream conditions and seasons. Sites were selected based on the presence of juvenile salmonids during our initial surveys. Sites ranged in size from 25 to70 feet in length and included a variety of habitats. Study sites began and ended at natural breaks in the habitat such as the beginning or end of cover or velocity shelters and pools. Typically three divers made separate passes beginning at the downstream end of the site. Divers kept individual counts of the number of each species of salmonids observed. The river mile and GPS coordinates of each dive site are listed in Appendix 1.

Site Selection at the Shasta Big Springs Ranch

We selected four sites downstream of Big Springs Creek between RM 32.9 and 33.6 where 0+ coho were rearing in early April 2008. All of the sites included velocity shelters, cover and woody debris. Water birch *(Betula occidentalis*) was present at all sites. Shasta Big Springs (SBS) sites 1- 4 are shown in Figure 6 and in photos 1-4.

Site Selection at Hole in the Ground Ranch

On 5/13/08 and 5/21/08, we selected five sites on the Hole in the Ground Ranch between river mile 35 and 37 on the Shasta River. These sites represented a variety of rearing habitats and conditions, including one site directly downstream of a cold spring inflow. The irrigation season had been under way for six weeks by the time these sites were established. We do not know what effect diversions and tailwater had on the distribution of salmonids in the reach prior to the selection of our sites. Hole in the Ground sites 1-5 are shown in Figure 7 and in Photos 5-9.

On 6/17/08 we were allowed access to a tributary spring to Parks Creek known as Kettle Springs. An earthen berm has been constructed around the spring to store and redirect flow from the natural channel into an irrigation ditch. Flow from the impoundment into Kettle Springs Creek was controlled by a head gate. An aerial photograph of the impoundment is shown in Photo 10. We observed juvenile coho rearing in Kettle Springs Creek in the pool directly below the head gate structure (Photo 11). Due to the presence of a substantial cold water source and rearing coho, we added Kettle Springs to the list of study sites.

Photo 1, Site SBS 1
This photo was taken on 4/3/2008, looking downstream from the top of the reach. The dive transect was 70 feet long on the right bank

Photo 2. SBS 2
This photo taken on 4/10/2008, looking downstream from the top of the reach. The dive transect was 36 feet long on the left bank.

Photo 3. SBS 3
This photo was taken on 4/17/2008 looking upstream from the lower end of the reach. The dive transect was 25 feet long on the left bank.

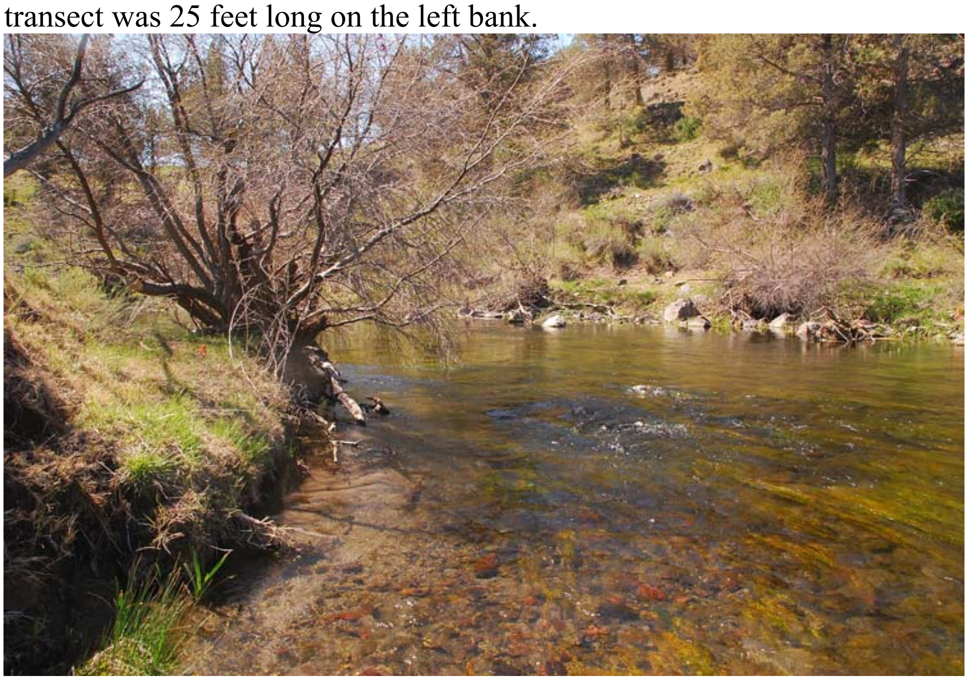


Photo 4. SBS 4

This photo was taken on 5/1/2008, looking upstream from the lower end of the reach. The dive transect was 47 feet long on the left bank.

Photo 5. HIG 1

This photo taken on 9/30/2008, looking upstream from the lower end of the reach. The reach was 30 feet long and included the entire channel.

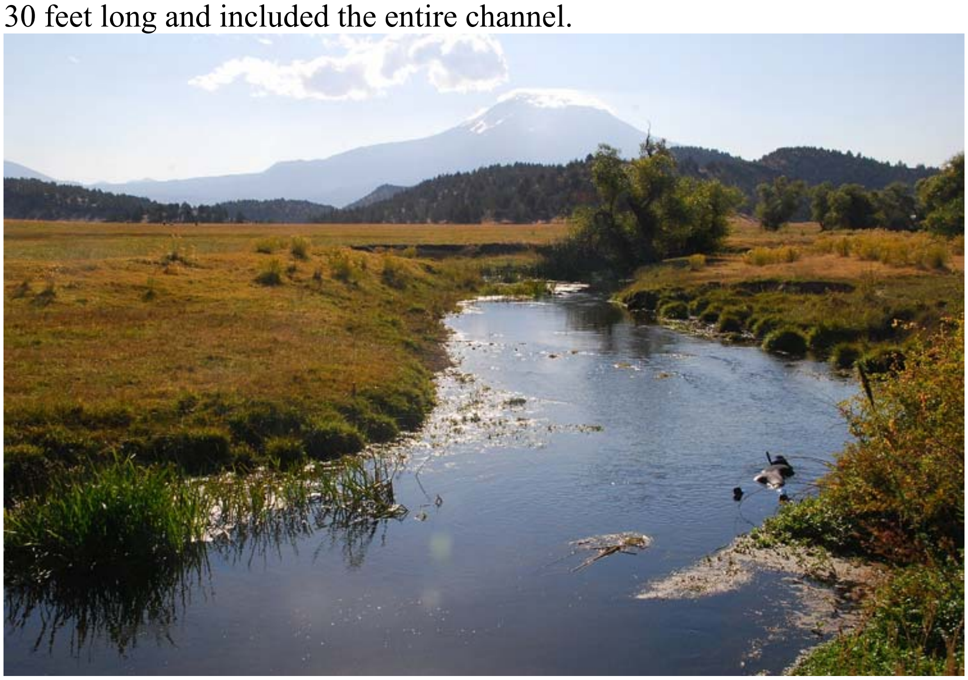


Photo 6. HIG 2

This photo was taken on 5/13/2008, looking upstream from the lower end of the reach. The reach was 30 feet long and included the entire channel.

Photo 7. HIG 3

This photo was taken on 5/28/2008, looking downstream from mid reach. The reach was 25 feet long and included the entire channel.

Photo 8. HIG 4

This photo was taken on 4/14/2009, looking upstream from mid reach. The reach was 65 feet long and included the entire channel.

Photo 9. HIG 5

This photo was taken on 4/28/2009 looking upstream from the lower end of the reach. The dive transect was 50 feet long on the left bank.

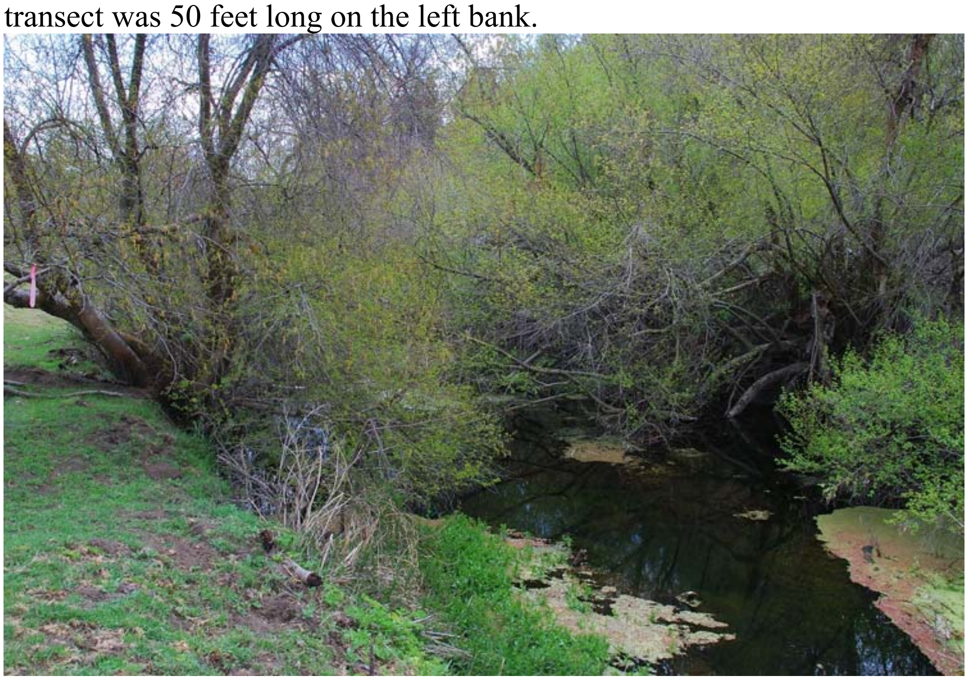


Photo 10. Clear Springs

This photo was taken on 4/14/2009 from the confluence of Clear Springs and the Shasta River.

Photo 11. Kettle Springs Impoundment

This photo was taken on 7/7/2008.

Photo 12. Kettle Springs Creek,

This photo was taken on 8/6/2008 looking downstream from the berm that impounds Kettle Springs. The dive reach included the entire channel from the diver's location to the outfall just out of view at the bottom of the photo.

Photo 13. Big Springs Lake Outfall,

This photo was taken on 8/7/2008, looking upstream towards the pool at the outfall of Big Springs Lake.

3.4 PIT tagging Methods

Overview

Passive integrated transponder (PIT) tags were used to individually mark juvenile (BY2007) coho salmon in the upper Shasta River in 2008. The purpose was to obtain information on coho movements, rearing habitats, and survival. To facilitate collection of this data, remote detection systems were deployed at key locations within accessible areas of the watershed based on both known and suspected life history traits. An important assumption for this study is that the behavior, growth, and survival of PIT tagged fish accurately reflect that of untagged fish within the population. This method was chosen for its ability to generate continuous and detailed data on individual fish as well as population segments with a single capture effort, thus reducing handling stress and potential mortality to this federally listed population.

To take advantage of new landownership access opportunities, ever changing environmental conditions and lessons learned through experience as the study progressed, several different techniques were used to capture coho for implantation of PIT tags throughout the study. Reconnaissance dives were often used to guide opportunistic capture efforts in the areas where limited access was acquired. PIT tag detection efforts also had to remain flexible as development of new technology and improved equipment availability provided opportunities to increase effectiveness of the monitoring effort.

PIT Tagging Methods

Coho of 55 mm fork length and larger were implanted with 12 mm 134khtz (Biomark #tx1411sst) PIT tags using methodology similar to that described by PIT Tag Steering Committee, 1999. Fish were anaesthetized with two 2.4g Alka-Seltzer tablets dissolved in approximately 1L of river water. All of the coho captured were scanned with a Biomark FS-2001 or Pocket Reader EX to determine the presence of previously tagged individuals. All PIT tags and 14 gauge syringe needles were disinfected with 90% ethanol prior to use. Each PIT tag was implanted by gently creating a small incision with the needle tip about 10 mm anterior to the base of the left pelvic fin. The PIT tag was then inserted into the body cavity through the incision by hand. The biological data recorded for each fish included collection of a scale sample from under the adipose fin on the fish's left side, measurement of fork length to the nearest mm, and wet weight to .01g, after the tag was inserted. Most fish were held for about 20 minutes or until normal behavior resumed and were then released back to the river at their original capture location.

Quality Control

To assess potential mortality and tag shedding that may be associated with tag insertion techniques used during this study, a sample of 84 tagged coho captured at the Nelson Ranch (RM 32) site were held in a net pen overnight and re-examined prior to release the following morning.

Nelson Ranch (RM 32) Capture Effort

CDFG's Anadromous Fisheries Resource Assessment and Monitoring Program (AFRAMP) has seasonally operated a five foot rotary screw trap (RST) on the Nelson Ranch at RM 32 since 2006. The operation of this trap in 2008 enabled us to capture coho and implant PIT tags for this study (photo 14). In addition to the RST, three fyke nets (Appendix 2) were also deployed to capture coho in a large eddy; about 200 yards upstream of the RST (Figure 8). These traps were fished at the stream margin, with a single lead run from the center of the trap's throat perpendicular to the river bank. Each fyke net was secured to T-posts driven into the river bottom (Photo 15). Fyke net sampling locations were chosen in areas of the channel with a uniform bottom, low water velocities, and depths which matched the lead height of the fyke net.

Beginning in mid February of 2008, fyke traps were fished two days (24 hour sets) per week until BY2007 coho of minimum tagging size (55mm) were caught, at which point sampling effort was increased to up to seven days per week Regular sampling effort ceased in early July of 2008 when coho were no longer caught on a consistent basis. Intermittent sampling effort continued through the winter of 2008 and regular sampling efforts resumed in April of 2009, when the RST and fyke traps were set at least twice per week. The trapping effort in 2008 at the Nelson ranch is described in detail in Kirkby (2009).

Photo 14. Nelson Ranch Rotary Screw Trap

Photo 15. Nelson Ranch Fyke Nets

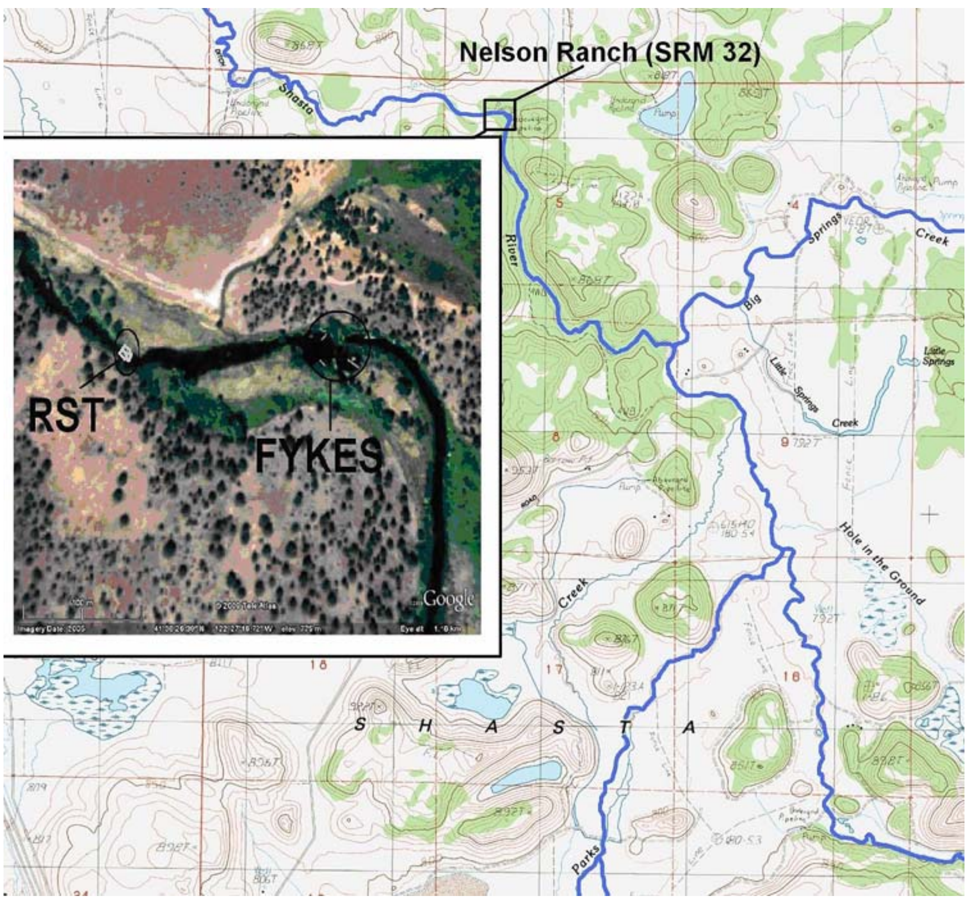


Figure 8. Nelson Ranch trap placement. (SRM = Shasta River Mile)

Tagging at Summer Rearing Locations

Capture of coho from rearing locations took place in the summer and fall of 2008 and was guided by opportunistic reconnaissance snorkel surveys in areas of the upper Shasta River and tributaries to which limited access was granted. A variety of capture techniques were used during the study and were selected for each site dependent on the effectiveness of the method for the specific channel characteristics and fish behaviors encountered. The capture methods utilized during the study included fyke nets, minnow traps, seine nets and hand held nets. A more thorough description of these capture techniques can be found in Appendix 3. The locations of these capture sites were at SBS dive site 1 (RM 32.9), the vicinity of HIG dive sites 1-5 (RM 35.0-36.8), Big Springs outfall, Big Springs Creek RM 1.5, and Kettle Springs (Figure 9).

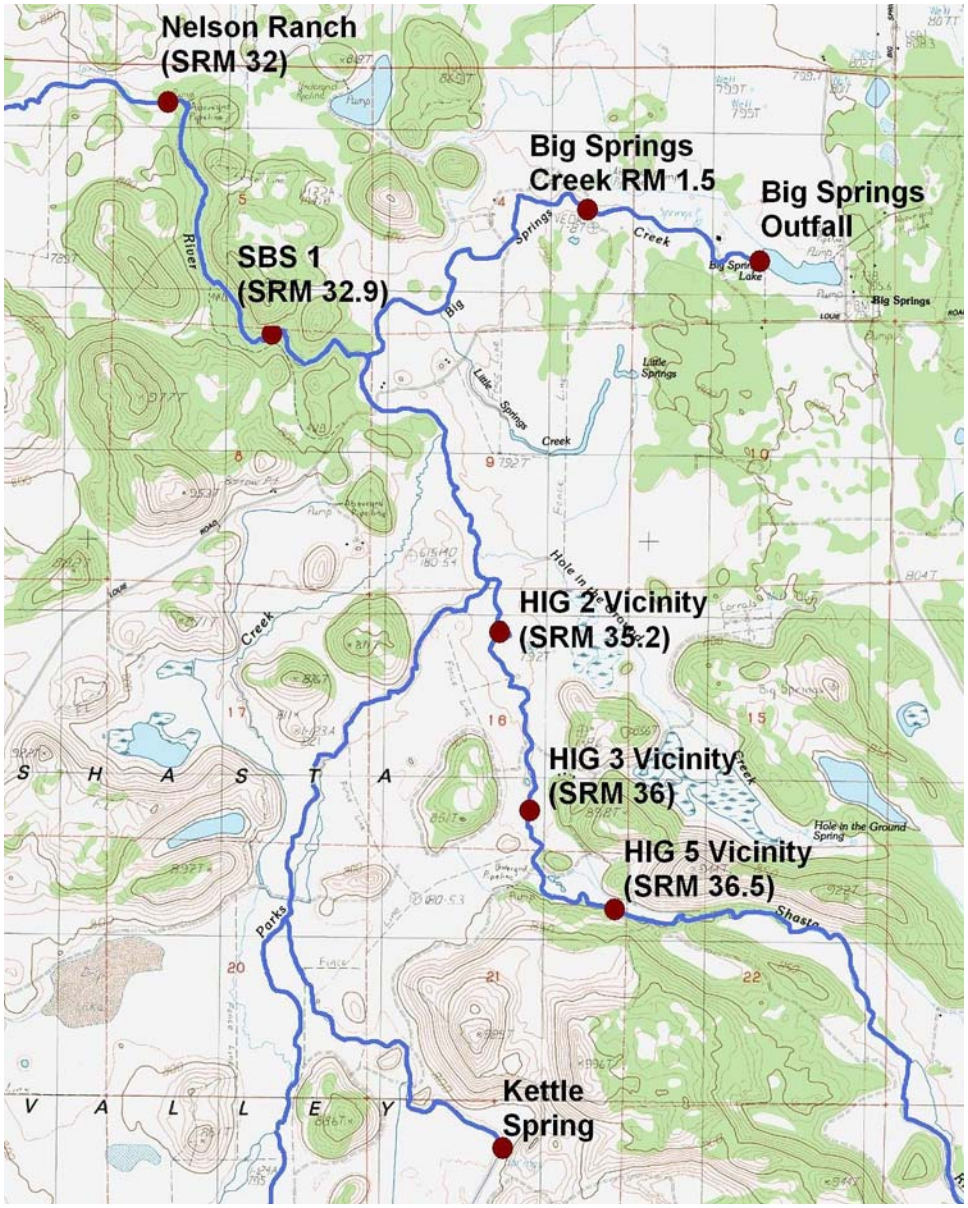


Figure 9. Tagging locations (SRM = Shasta River Mile)

<u>Remote Detection Effort</u>

Remote PIT tag detection systems were comprised of in-stream antennas operated with Allflex panel readers and data storage unit custom-made by Mauro Engineering. In most locations, power was supplied by solar panels coupled with 12 volt batteries. Most of the antennas measured 10'x 3' and were constructed with copper tubing housed in PVC pipe. Antennas were set perpendicular to the stream flow and secured to t-posts driven into the river bottom (Photo 16, 17). Detections of individual PIT tags were recorded onto a compact flash card along with the antenna number, date and time stamp. A test tag was also installed on each antenna which was programmed to turn on briefly every ten minutes to provide verification that the equipment was operating correctly. For a detailed description of the antenna systems, see Adams 2009.

Photo 16. Antenna System at HIG 5, Winter 2009

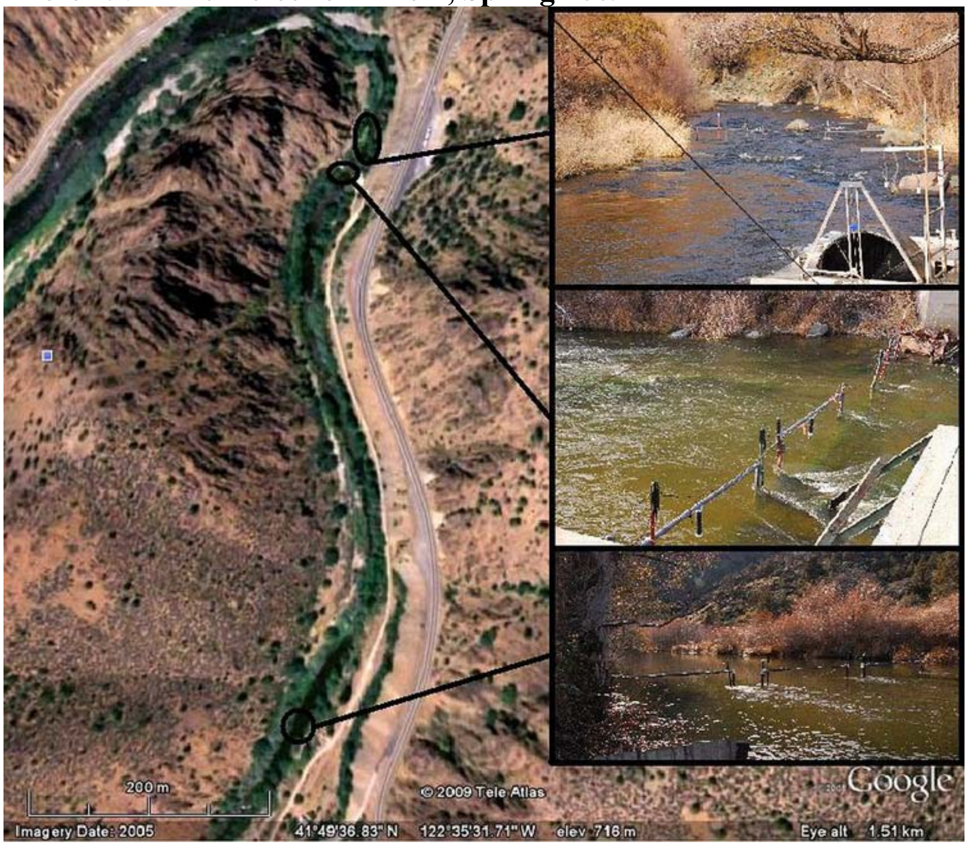
Photo 17. Antenna System at RM 0, Spring 2009

Four remote detection systems, consisting of one to three antennas partially covering the river transect, were in place during the spring of 2008. These were located just downstream of the Nelson Ranch RST (RM 32), lower Nelson Ranch (RM 29), Meamber Ranch (RM 15), and just upstream (RM 0) of the confluence of the Shasta River with the Klamath River. After the study began, access to study sites upstream of the Nelson Ranch provided an opportunity to expand the study and install additional remote detection systems in known rearing locations at RM 32.9, 36, and 36.8, Big Springs Creek outfall, and Kettle Springs Creek outfall. In addition to these locations, antenna systems were installed at sites through which coho movements were anticipated. These included RM 32.1, just upstream of Parks Creek at RM 35, Parks Creek RM 0, Parks Creek RM 4, and Big Springs Creek RM 1.6. Remote detection sites at Parks Creek RM 0, 7 and RM 34.5 were characterized by low flow and a confined channel. This allowed for the installation of directional antenna systems, in which three cross-stream antennas were placed in succession (Photo 18) The complete stream coverage by each antenna and time stamp associated with each detection permitted the identification of either upstream or downstream movement of each individually PIT tagged fish.

Photo 18. Directional Antenna System at HIG 1

A five foot RST was operated by AFRAMP during the 2008 and 2009 emigration season approximately 250 yards upstream from the Shasta River's confluence with the Klamath River (RM 0) and this effort served as a recapture location for PIT tagged fish as they emigrated from the Shasta. All coho captured at this trap were scanned with a Biomark FS-2001 PIT tag reader. Recaptured PIT tagged fish were measured for fork length, wet weighed, and sampled for scales on the right side between the dorsal and adipose fins, above the lateral line. In February of 2009, three independent antenna systems were also installed at the RM 0 sites, approximately 40 yards downstream and 20 and 600 yards upstream of the RST. These systems consisted of three antennas each and covered the majority of the river's transect. Photo 19 illustrates the configuration of these antennas and RST during the spring of 2009.

Photo 19. RM 0 Detection Effort, Spring 2009



Data Analysis

Biologists with the U.S. Geological Survey (USGS) in Klamath Falls, Oregon, developed a Microsoft Access database while working with endangered suckers in the upper Klamath Basin to store and analyze PIT tagging and detection data. This database program was provided by the USGS biologists to assist our effort. Quantitative as well as qualitative data were analyzed by running queries relating tagging times and locations to detection times and locations.

Smolt Survival and Detection Probability Estimates

We used a Cormack-Jolly-Seber live-recapture model (Schwarz and Seber 1999) in program MARK (White and Burnham 1999) to obtain maximum likelihood estimates of apparent survival (Φ_i) and recapture probability (p_i) over three river segments for coho smolts emigrating from rearing habitats on HIG in the spring of 2009 (3/15/09 to 5/30/09). Tagged coho included in this analysis were detected at least once on the HIG 5, HIG 3, or HIG 1 antenna systems on or after 3/15/09. These initial detections were combined with detections at the RM 0 antenna systems and RST to generate a seven encounter capture history matrix to which this model was applied (Table 4).

Table 4. Target survival and recapture probability estimates.

Encounter locations used to generate seven encounter capture history matrices, including approximate distances between, points of releases, and target apparent survival (Φ) and recapture (detection) probability (*p*) estimates.

Encounter Locations	HIG 5	Reach 1	HIG 3	Reach 2	HIG 1	Reach 3	WEIR C	Reach 4	WEIR B	Reach 5	RST	Reach 6	WEIR A
Approx Reach Length		0.5 miles		1 mile		35 miles		1800 feet		60 feet		120 feet	
Releases	R		R		R								
Estimates	NA	Φ	*p*	Φ	*p*	Φ	*p*	Φ set to 1	*p*	Φ set to 1	*p*	Φ set to 1	NA

The range of dates chosen as criteria for inclusion in the analysis were selected based upon observed coho emigration during previous RST sampling, direct observation of decreasing numbers and absence of coho in rearing areas, and data from remote detections of tagged fish. All of the remote antenna systems operated consistently throughout this time period. Apparent survival (Φ) is the complement of the sum of mortality and permanent emigration (Pollock et al. 2007). Since Φ's were estimated over river reaches in our study design, residency was confounded with mortality. Additional sampling efforts in the main stem Shasta River and several tributaries coupled with direct observations in rearing areas indicate that incidences of residency were negligible. All individuals in this analysis were tagged at least three months prior to the time period of interest; therefore handling mortality and tag loss were also assumed to be negligible. For these reasons, we believe our estimates of Φ closely reflect true survival.

Coho included in the initial releases were comprised of all tagged coho that were detected at the HIG 5, HIG 3, or HIG 1 remote systems on or after 3/15/09 which was assumed to indicate that the individuals were alive. This included fish tagged in that vicinity as well as fish that migrated there from other locations prior to 3/15/09. Detections of coho at the HIG 5 antenna system were used as the initial release in the capture history matrix and were used to estimate survival of coho smolt emigrating between HIG 5 and HIG 3. The second encounter was comprised of detections at the HIG 3 antenna system, which included fish from the first release as well as coho not included in the first release. The third encounter was comprised of detections at the HIG 1 antenna system and fish from the first two releases and an additional release of all coho detected that were not included in the first two releases. The fourth, fifth, sixth, and seventh encounters were comprised of detections at the three RM 0 antenna systems and RST. Survival was assumed to be 1 over these last four encounters, given their proximity to each other, which allowed for an overall estimation of detection probability for all RM 0 detection efforts during the spring of 2009.

To compensate for overdispersion, a quasilikelihood correction factor ($\hat{c}$) value of 1.54 was estimated using the median $\hat{c}$ estimation method (Cooch and White 2006). The most general model allowed for difference in Φ in reaches 1, 2, and 3, Φ fixed to 1 in reaches 4, 5, and 6 (all RM 0 efforts), and allowed all *p's* to be different. Using this model as a starting point, models with fewer parameters were constructed by constraining Φ and or *p* across some reaches and detection locations. These less parameterized models were used to test for a more parsimonious model.

We used Akaike's information criterion corrected for small-sample bias (AIC_c) and adjusted for overdispersion (i.e., quasilikelihood AIC_c [$QAIC_c$]; (Burnham and Anderson 2002) as a statistical criterion to evaluate the competing models. Akaike weights (w_i) are reported to provide a measure of each model's relative likelihood of being the best model in the set given the data (Burnham and Anderson 2002). Rather than making inference from parameter estimates using only the best model (i.e., that with the smallest QAICc value) in the set, predicted parameter estimates were weighted based on model weights. Model-averaged parameter estimates account for model selection uncertainty in the estimated precision of the parameter and thus produce unconditional estimates of variance and standard error (Buckland et al.. 1997).

4.0 Results

4.1 Water Temperature Monitoring Results

To get an understanding of the range and characteristics of water temperature conditions in the Shasta River between RM 32.9 and RM 37.4, we looked at daily, weekly and seasonal maxima and minima.

Maximum Weekly Maximum Temperatures and Maximum Weekly Average Temperatures
The maximum weekly maximum temperature (MWMT) and the maximum weekly average temperature (MWAT) for all sites are shown in Table 5. Figure 10 shows the MWMT at monitoring sites on the Shasta River main stem from the most upstream site at RM 37.4 (Fence) to the furthest downstream site at RM 32.9 (SBS 1).

The MWMT for each site is calculated by averaging the daily maximum temperatures for each week and selecting the week with the highest value for the study period, Julian Week 20 through 33 (5/14/08 through 8/19/08). The MWAT for each site is calculated by averaging the mean daily temperatures for each week and selecting the week with the highest value. A list of Julian weeks with equivalent calendar dates is shown in Appendix 21.

Maximum Daily Temperatures Exceeding 23 Degrees Centigrade
The greatest number of days with maximum temperatures over 23 °C was at the most upstream temperature logger (Fence) on Hole in the Ground Ranch; sites HIG 5 and 4 never exceeded 23 °C (Figure 11). The number of days per site that the maximum daily temperatures exceeded 23° increased downstream of HIG 3.

Table 5. MWMTs and MWATs for all sites in 2008

Site	River Mile	Start Date	MWMT	JW	MWAT	JW
Fence	37.4	5/28/2008	27.092	28	22.903	28
Clear Springs	37.0	6/5/2008	13.649	25	13.597	25
HIG 5	36.8	5/22/2008	20.576	28	18.934	28
HIG 4	36.3	5/21/2008	21.221	28	19.457	28
HIG 3	36.0	5/21/2008	22.471	28	19.563	28
HIG 2	35.2	5/14/2008	22.510	26	18.422	28
HIG 1	35.0	5/14/2008	22.951	26	19.169	28
SBS 6	34.9	3/27/2008	23.748	20	19.917	20
SBS 5	33.7	3/27/2008	24.400	20	20.205	28
SBS 4	33.6	3/27/2008	23.518	20	16.976	27
SBS 2	33.3	6/13/2008	23.274	28	18.242	28
SBS 1	32.9	4/23/2008	23.395	20	18.313	20
BSO	N/A	4/1/2008	16.558	27	15.161	27
BSC	N/A	3/27/2008	23.591	20	16.852	27
PC	N/A	3/27/2008	27.033	28	22.266	28
Kettle Springs	N/A	8/9/2008	14.581	33	13.965	33

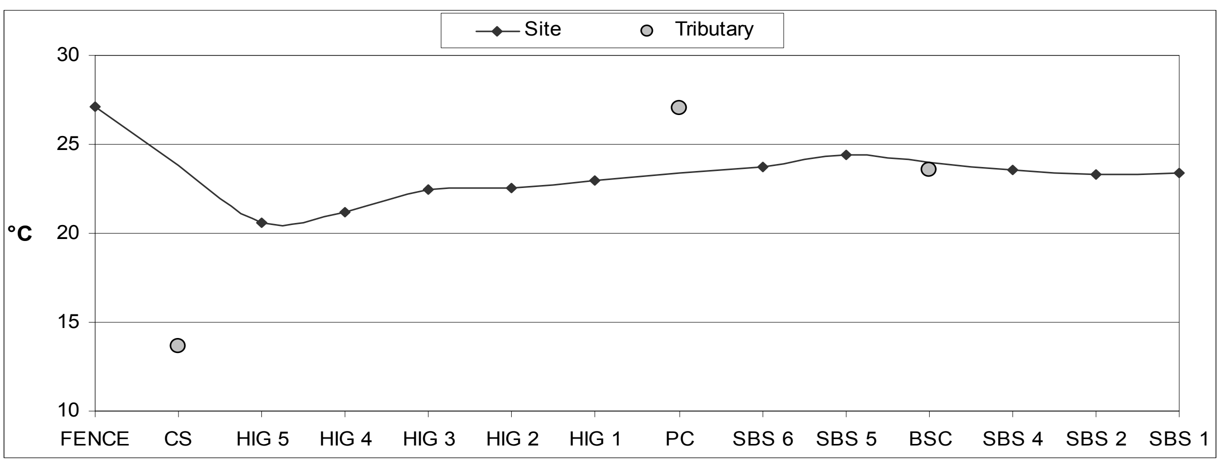


Figure 10. MWMTs for summer 2008 Shasta River from RM 32.9 to RM 37.4

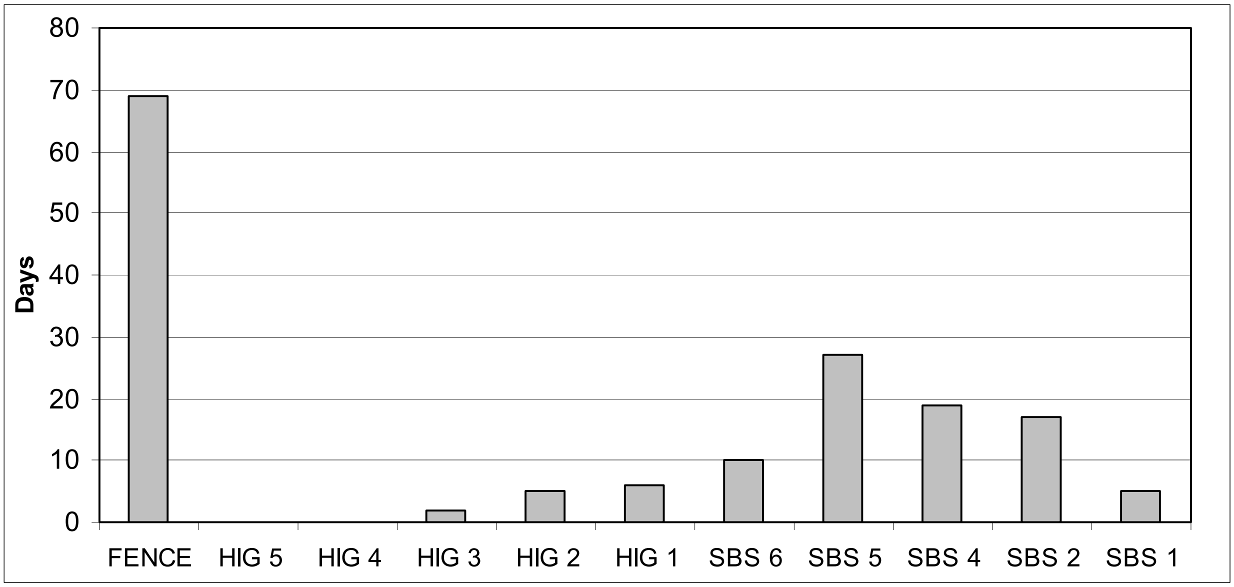


Figure 11. Number of days by site in 2008 that maximum daily water temperatures were greater than or equal to 23 degrees

Diurnal Temperature Change

The greatest diurnal change in temperature recorded at each site per week during Julian Weeks 13 through 33 is shown in Table 6.

Table 6. Maximum Diurnal Water Temperature Change by Site

Location	JW	Max Diurnal Date	Maximum	Minimum	Diurnal Change
FENCE	24	6/13/2008	25.258	13.185	12.073
Clear Springs	26	6/26/2008	13.69	13.594	0.096
HIG 5	24	6/13/2008	20.34	13.51	6.83
HIG 4	23	6/8/2008	18.699	13.233	5.466
HIG 3	28	7/13/2008	24.412	16.749	7.663
HIG 2	26	6/27/2008	25.404	15.151	10.253
HIG 1	25	6/23/2008	24.919	13.185	11.734
Parks Cr.	29	7/18/2008	26.891	16.558	10.333
SBS 6	15	4/12/2008	19.984	10.467	9.517
SBS 5	15	4/11/2008	19.77	8.593	11.177
BSC	18	5/5/2008	22.92	9.435	13.485
BSO	33	8/17/2008	17.938	13.305	4.633
SBS 4	18	5/5/2008	22.896	9.731	13.165
SBS 2	26	6/27/2008	24.219	12.992	11.227
SBS 1	17	4/26/2008	21.461	9.756	11.705
Kettle Springs	33	8/13/2008	14.673	13.377	1.296

Change in Location of Maximum Weekly Temperatures

Hole in the Ground Ranch

The maximum water temperatures per week at the HIG monitoring sites downstream of Clear Springs are presented in Appendix 4 and presented graphically in Appendix 5. The location of the weekly maximum temperature varies by week. Examples of this variability are shown in Figures 12 a-c.

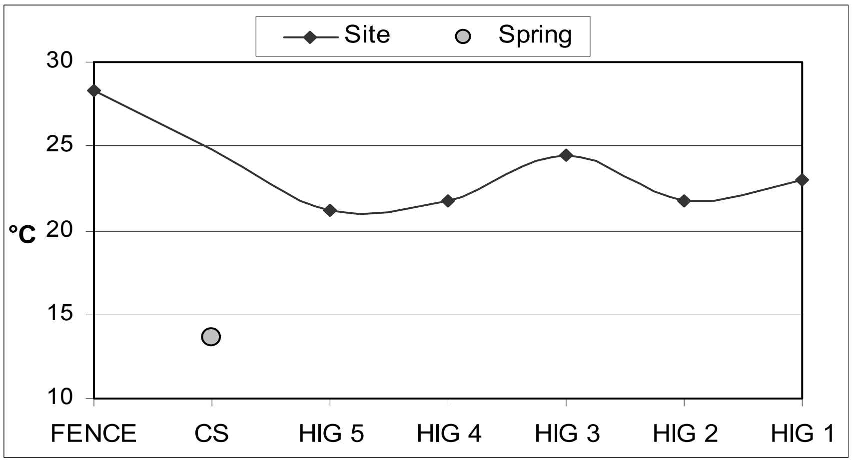


Figure 12a. Maximum weekly water temperatures at HIG sites during Julian week 28

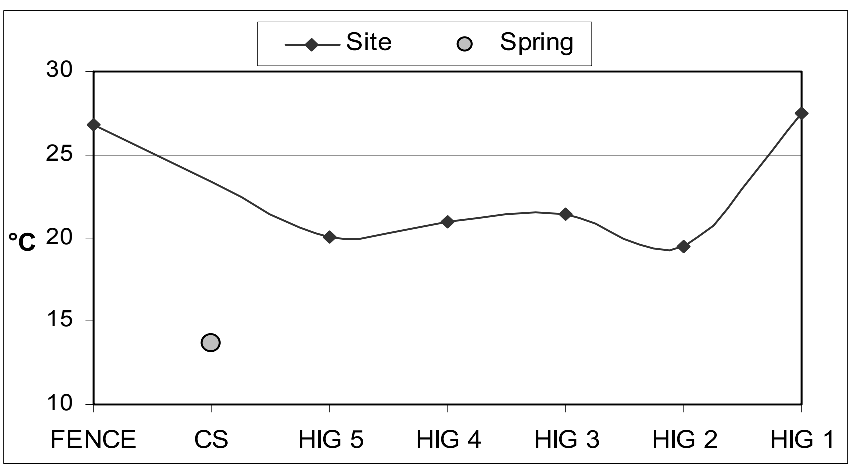


Figure 12b. Maximum weekly water temperatures at HIG sites during Julian week 29

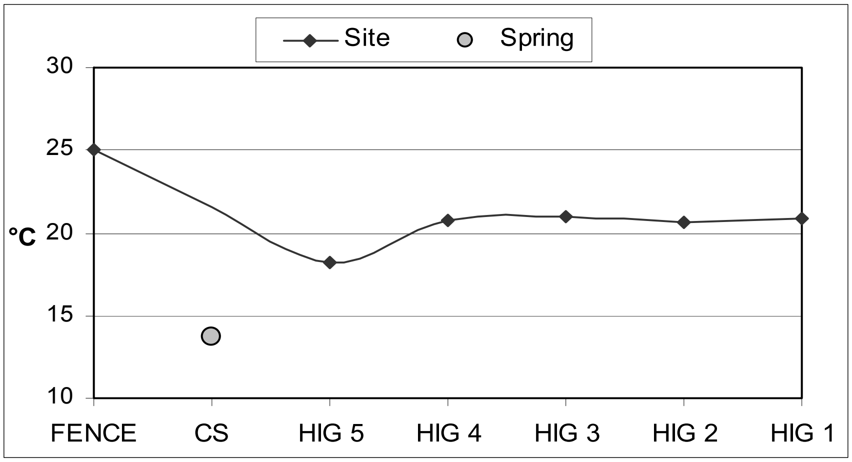


Figure 12c. Maximum weekly water temperatures at HIG sites during Julian week 30

Daily Maxima

We observed distinct spikes in water temperature that were limited to a single site. Examples of the change in location of daily maximum water temperatures at the HIG are shown in Figure 13 a-c. Figures 13 a-c show the temperature recorded at different sites at the same time on three different dates. On 7/13/08 at 1500, the highest water temperature downstream of Clear Springs was 24.41 degrees at HIG 3 (Figure 13a). On 7/16/08 at 1600, the highest temperature was 27.35 at HIG 1 (Figure 13b) and on 7/23/08 at 1700 the high temperatures at HIG 1, 2 and 3 were similar at 19.98, 19.17, and 19.65 respectively (Figure 13c).

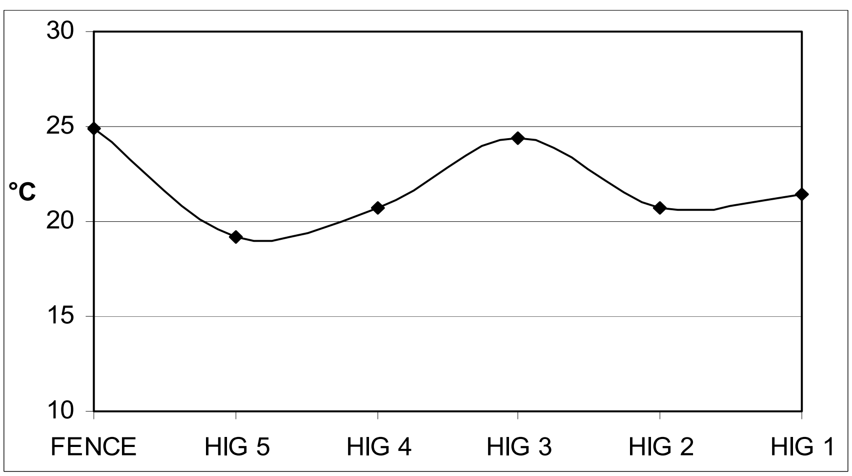


Figure 13a. Maximum daily water temperatures at HIG sites on 7/13/08 at 15:00

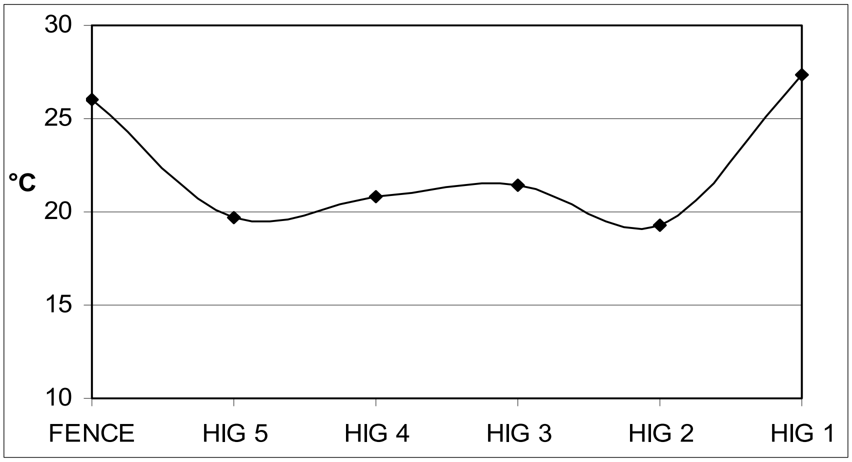


Figure 13b. Maximum daily water temperatures at HIG sites on 7/16/08 at 16:00

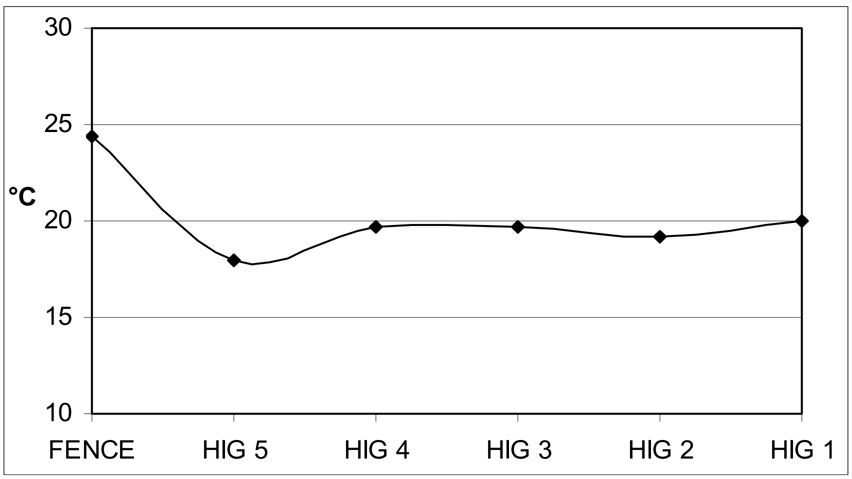


Figure 13c. Maximum daily water temperatures at HIG sites on 7/23/08 at 17:00

Figure 14 shows the water temperatures at six HIG sites over a twenty hour period beginning at 06:00 on 7/16/08. This is the same high temperature event shown in Figure 13b. The highest water temperature and the largest diurnal changes were recorded at HIG 1. The minimum recorded water temperature at HIG 1 for the day was 16.9 degrees at 06:00 and the maximum temperature was 27.4 at 15:00. The increase in temperature at HIG 1 was a localized event and was not the result of warm water from an upstream location.

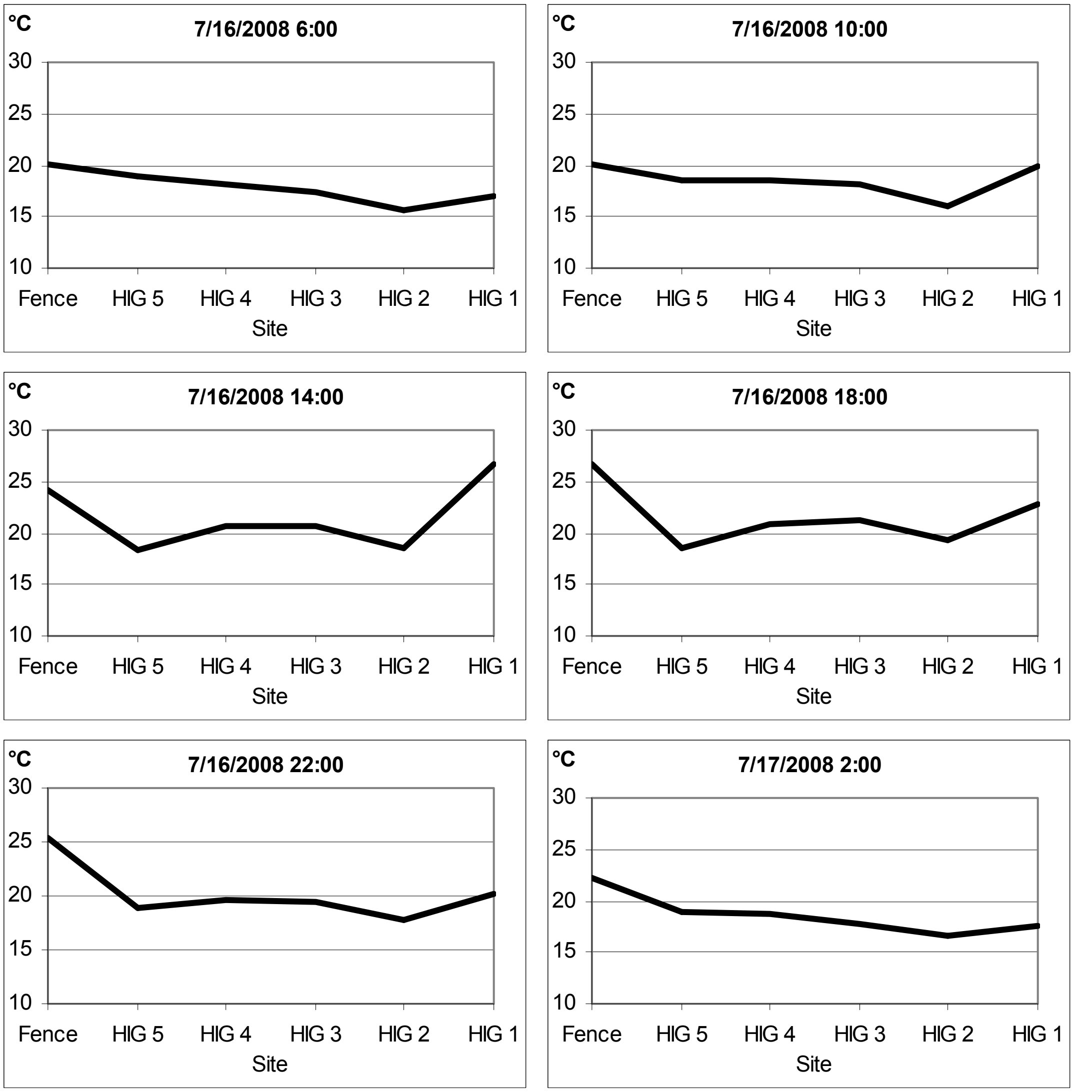


Figure 14. Sequence of water temperatures at four hour intervals at Hole in the Ground Ranch sites from 06:00 on 7/16/08 through 02:00 on 7/17/08

Thermal Diversity

The original intention of temperature logger deployment was to determine the basic thermal characteristics present throughout the upper Shasta River. Complying with a request from EII personnel, we deployed two loggers at each habitat site on Hole in the Ground Ranch and Shasta Springs Ranch. Comparative analyses of the paired loggers revealed unexpected variations in water temperature readings between loggers (Table 7). Some loggers were initially deployed a few feet apart (as occurred at sites HIG 2 and 5) but later deployed side-by-side to minimize variation. This thermal diversity was most pronounced at HIG 2. No attempt is made here to fully elucidate the causes of this diversity, nor is there an attempt to quantitatively define all thermal inputs present in the system. The existence of significant thermal diversity demonstrates the need for further study at these sites. The deployment of more loggers and ground-truthing of LIDAR generated tailwater maps are necessitated by these initial findings.

Table 7 displays the average maximum temperature difference of paired loggers per week. Values were generated by finding the difference in daily maximum temperatures between loggers. Daily minimum temperatures are the least variable between loggers. Minimum differences between loggers often approach or reach zero. The maximum differences are averaged by week and displayed in the table below. The numbers should not be read as correction values indicating one logger always recorded x degrees above or below another logger. These values simply show maximum temperature differences that may occur.

The logger recording consistently higher temperatures at each site was used to generate its corresponding site MWMT and MWAT values as well as all graphs and charts. Variable temperatures were not averaged, as each logger was recording actual temperatures. Although a temperature resembling the averages of the two differing logger readings may exist along some gradient in the thermal milieu, it can be stated that each device accurately depicts the localized thermal conditions present at any moment that juvenile salmonids, if present, must tolerate.

Table 7. Average Maximum Temperature Difference (°C) between Loggers per Week

JW	FENCE	HIG 5	HIG 4	HIG 3	HIG 2	HIG 1
20	-----	-----	-----	-----	0.072	0.041
21	-----	0.259	0.043	0.075	0.129	0.088
22	0.127	0.233	0.041	0.140	0.309	1.244
23	0.130	0.257	0.069	0.048	0.669	1.070
24	0.127	0.268	0.051	0.095	1.368	1.192
25	0.127	0.909	0.039	0.034	2.187	1.383
26	0.128	0.991	0.051	0.075	3.423	1.631
27	0.405	0.861	0.097	0.061	4.230	1.252
28	0.291	1.656	0.338	0.113	3.700	0.809
29	0.194	0.617	0.167	0.048	2.916	1.689
30	0.169	0.392	0.072	0.027	2.542	1.108
31	0.152	0.804	0.077	0.017	2.841	1.159
32	0.127	0.316	0.141	0.017	2.701	0.435
33	0.132	0.119	-----	0.024	2.434	0.232

4.2 Flow Monitoring Results

Shasta Big Springs Ranch

Flows in the Shasta River downstream of Big Spring Creek, as reported in Mount et al. 2009, are shown in Figure 15. These flows were calculated by adding the flow of Big Springs Creek, Parks Creek and the Shasta River upstream of Parks Creek.

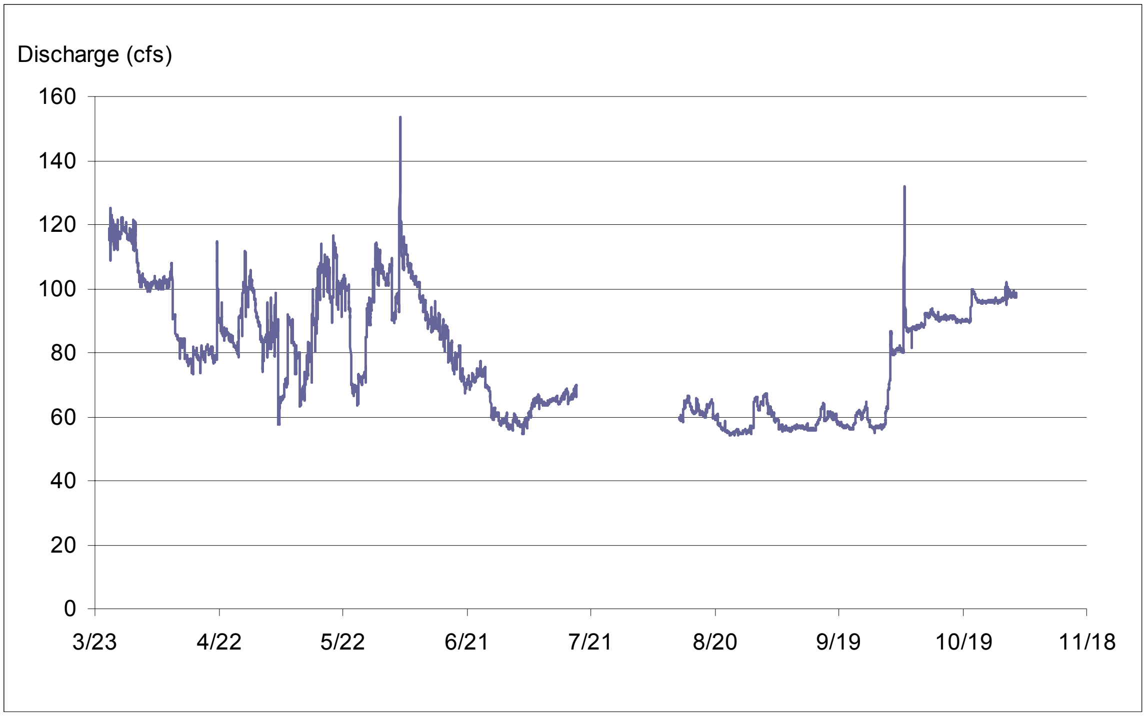


Figure 12. Shasta River flow downstream of Big Springs Creek, 3/26/08 through 10/31/08

Hole in the Ground Ranch

On 6/11/08, 7/8/08 and 7/21/08, we measured Shasta River discharge at HIG Sites 1 through 5 as shown in Figure 16a-c. Two water diversion structures are located upstream of site HIG 4; some diverted water was observed re-entering the Shasta River on five occasions, the dates and locations of these tailwater returns are shown in Figure 17.

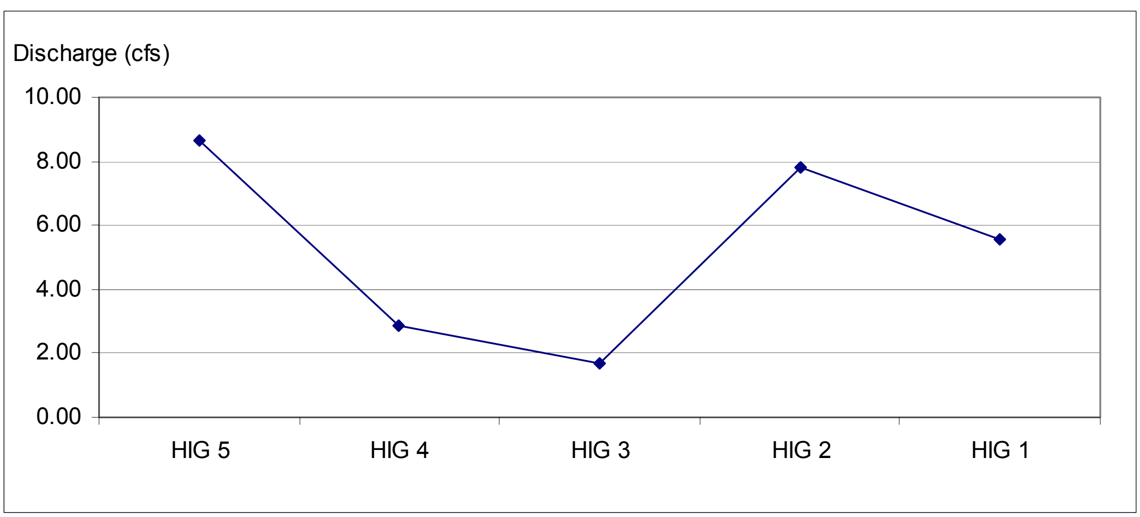


Figure 16a. Discharge (cfs) measured in the Shasta River at five sites at the Hole in the Ground Ranch on June 11, 2008

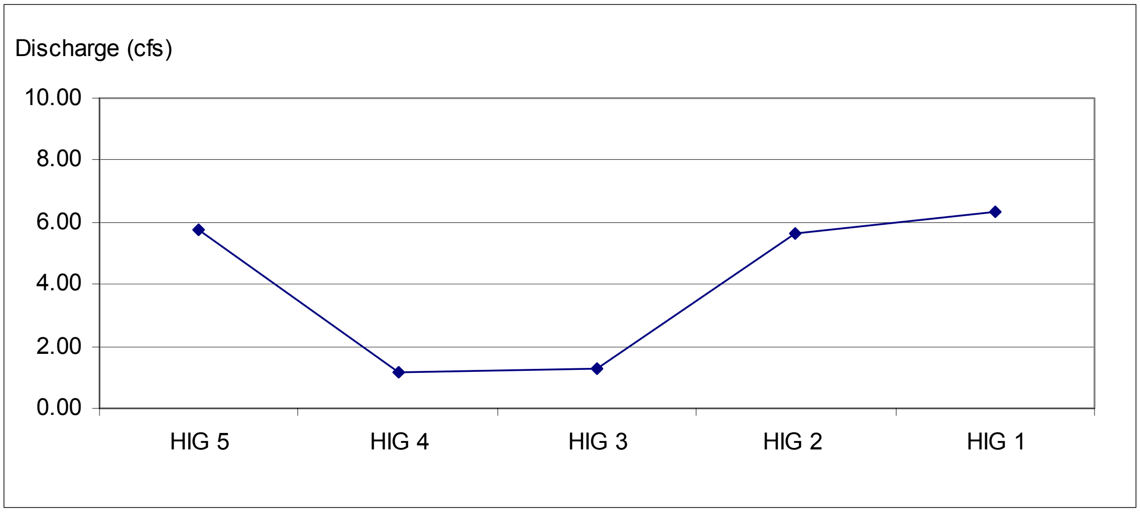


Figure 16b. Discharge (cfs) measured in the Shasta River at five sites at the Hole in the Ground Ranch on July 8, 2008

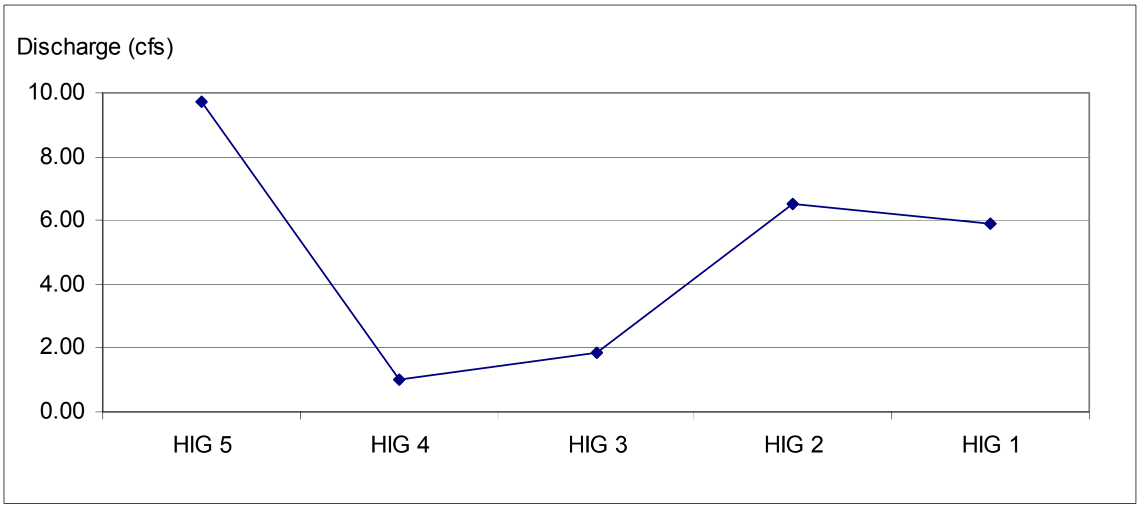


Figure 16c. Discharge (cfs) measured in the Shasta River at five sites at Hole in the Ground Ranch on July 21, 2008

<u>Kettle Springs</u>
The discharge of Kettle Springs was measured on 8/6/08. The full discharge of the spring was being release in Kettle Springs Creek at this time and the impoundment was drained. The flow in the channel inside the impoundment was 4.88cfs and the flow in Kettle Springs Creek approximately 50 yards downstream from the impoundment was 5.84 cfs.

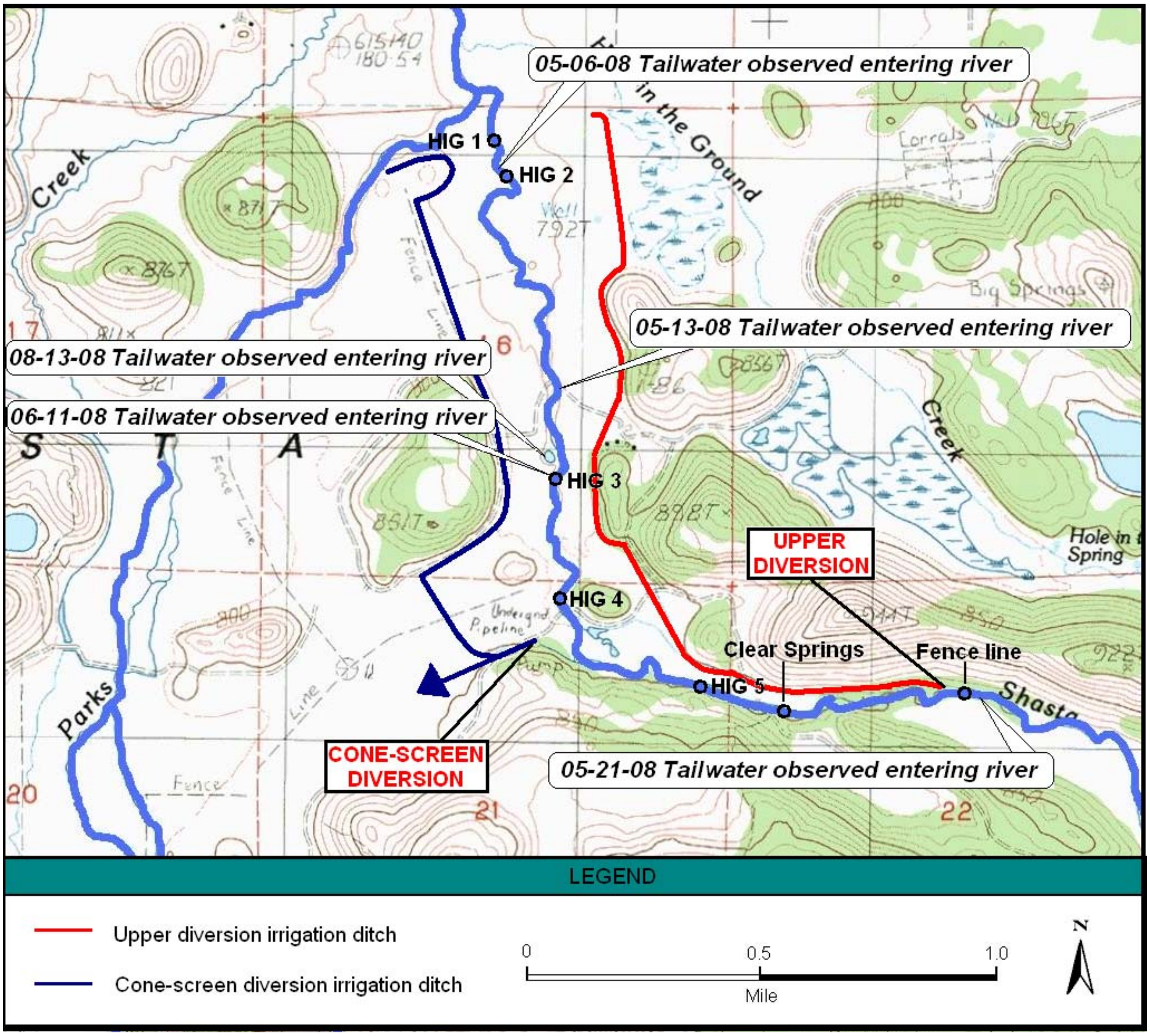


Figure 17. Partial diagram of some diversions, irrigation ditches and tailwater return sites observed along the Shasta River at Hole in the Ground Ranch in 2008.

4.3 Direct Observation Results

Shasta Big Springs Ranch

The mean number of coho, Chinook and steelhead per dive at each SBS site are shown in Figures 18 – 21. Appendix 8 shows the individual counts and standard deviation between counts for each date and location. The number of juvenile coho rearing at SBS 1-4 decreased during Julian 19. By week 22, SBS 2 was the only SBS site where coho were still rearing. We observed coho at SBS 2 throughout the study period.

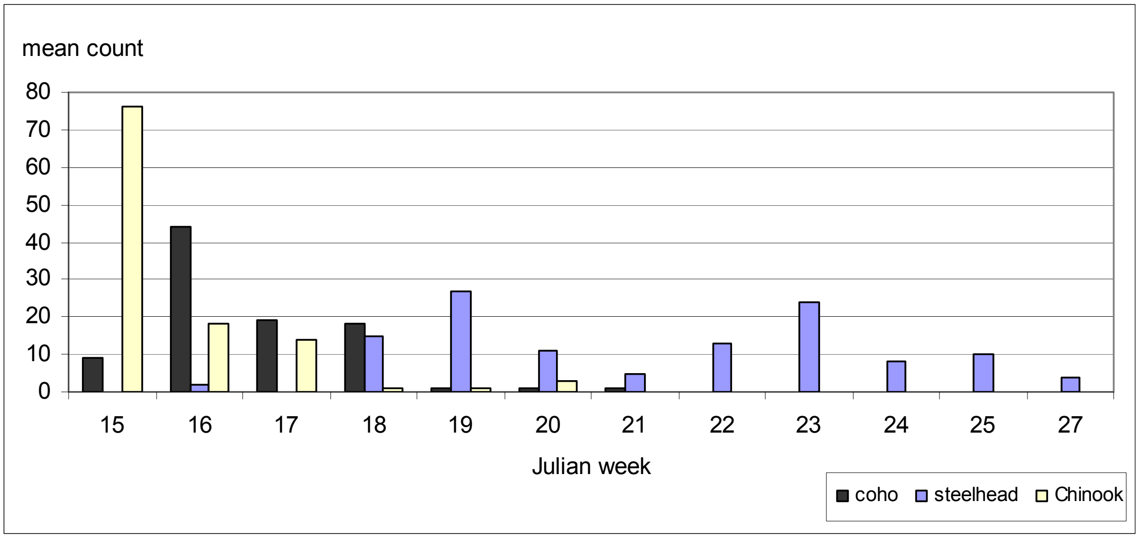


Figure 18. SBS 4: mean number of 0+ salmonids observed per dive count in the Shasta River on Shasta Big Springs Ranch in 2008

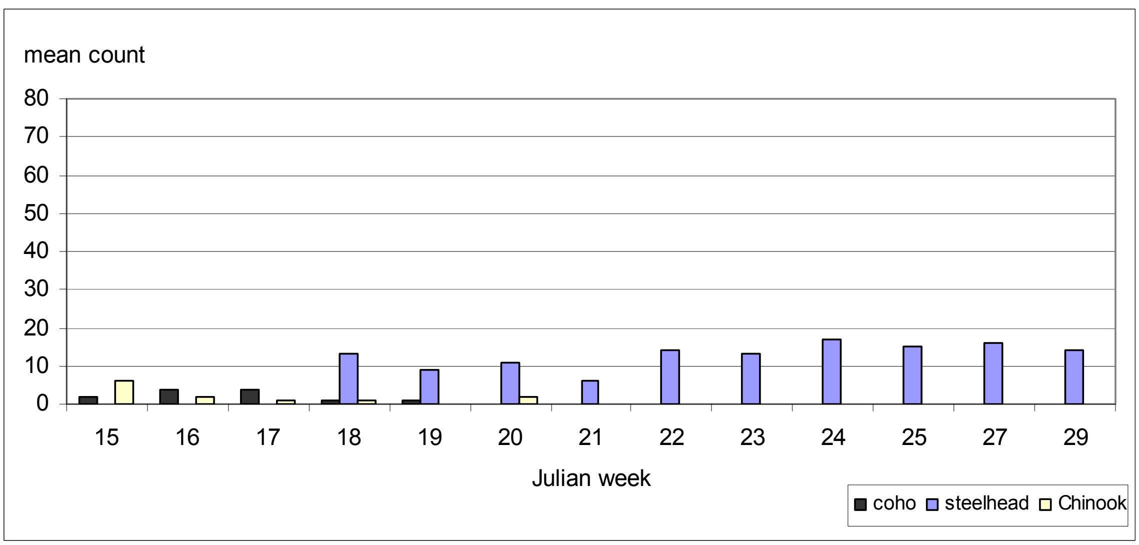


Figure 19. SBS 3: mean number of 0+ salmonids observed per dive count in the Shasta River on Shasta Big Springs Ranch in 2008

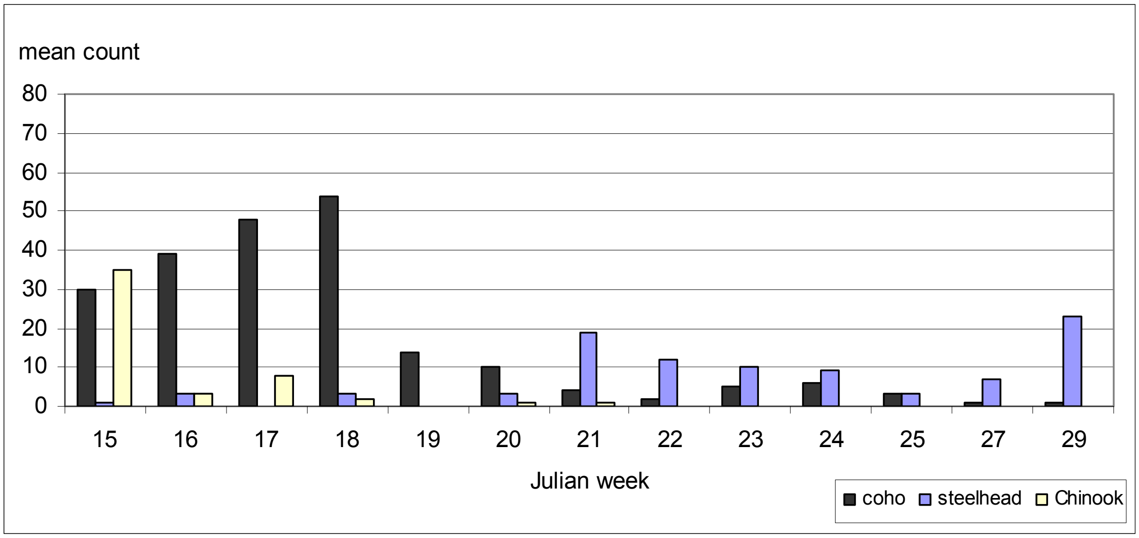


Figure 20. SBS 2: mean number of 0+ salmonids observed per dive count in the Shasta River on Shasta Big Springs Ranch in 2008

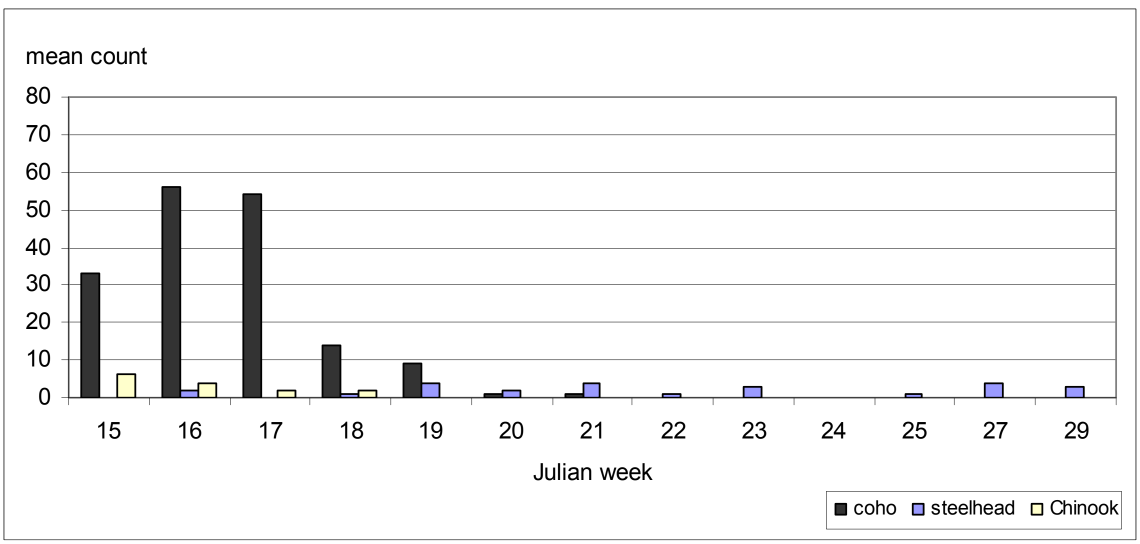


Figure 21. SBS 1: mean number of 0+ salmonids observed per dive count in the Shasta River on Shasta Big Springs Ranch in 2008

Hole in the Ground Ranch

The mean number of coho, Chinook and steelhead per dive at each HIG site are shown in Figures 22 – 26. Appendix 9 shows the individual counts and standard deviation between counts for each date and location. We observed coho at HIG sites 3, 4 and 5 throughout the study period. Coho were only observed at site 2 during Julian Week 21.

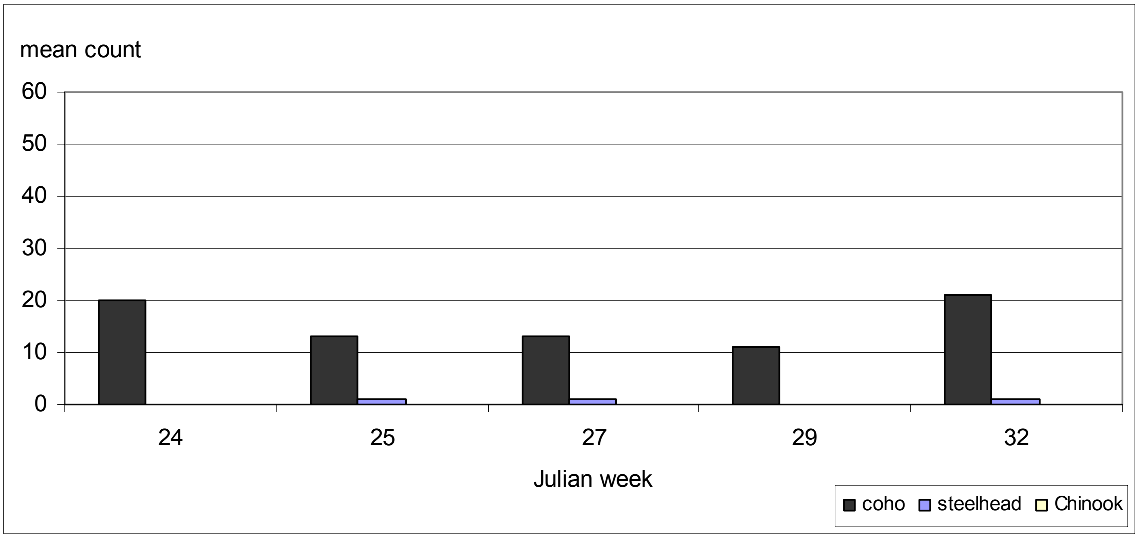


Figure 22. HIG 5: mean number of 0+ salmonids observed per dive count in the Shasta River on Hole in the Ground Ranch in 2008

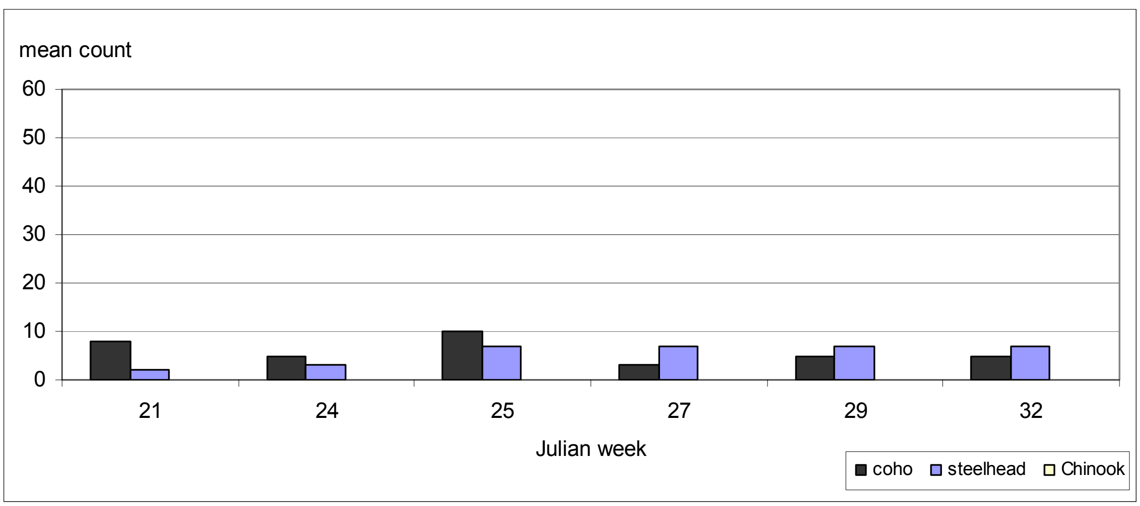


Figure 23. HIG 4: mean number of 0+ salmonids observed per dive count in the Shasta River on Hole in the Ground Ranch in 2008

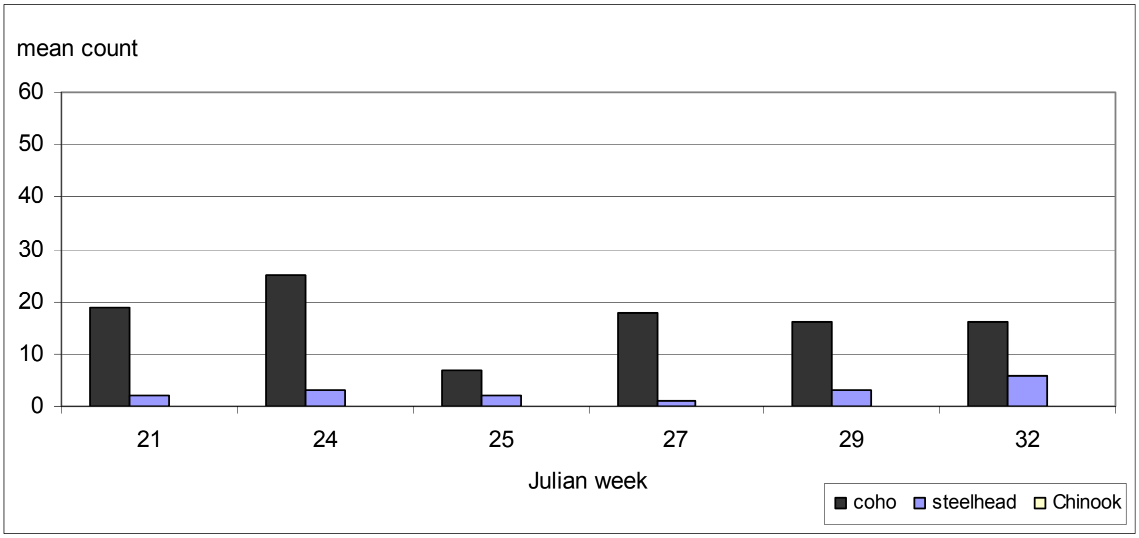


Figure 24. HIG 3: mean number of 0+ salmonids observed per dive count in the Shasta River on Hole in the Ground Ranch in 2008

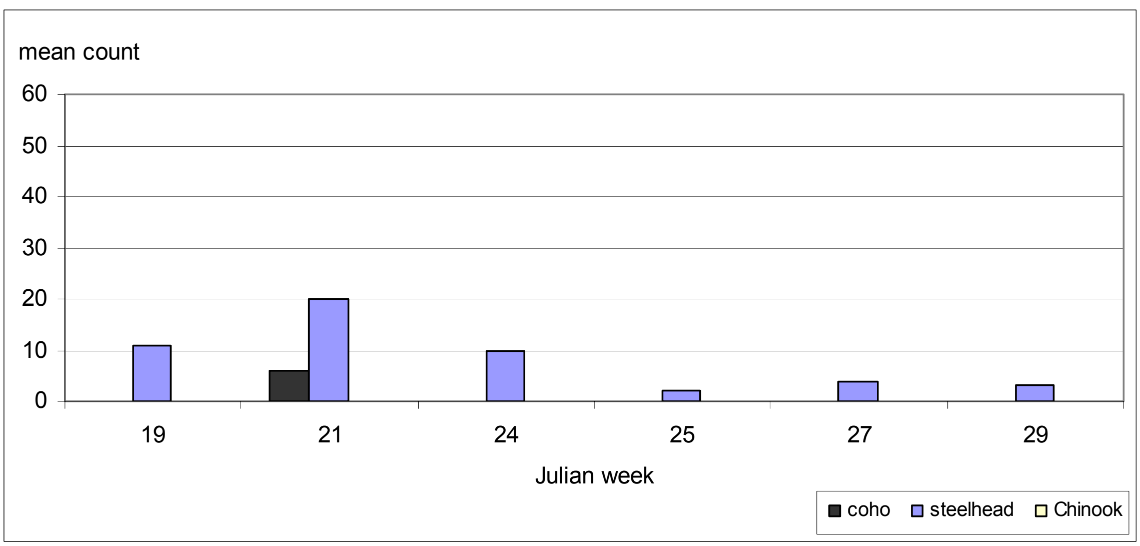


Figure 25. HIG 2: mean number of 0+ salmonids observed per dive count in the Shasta River on Hole in the Ground Ranch in 2008

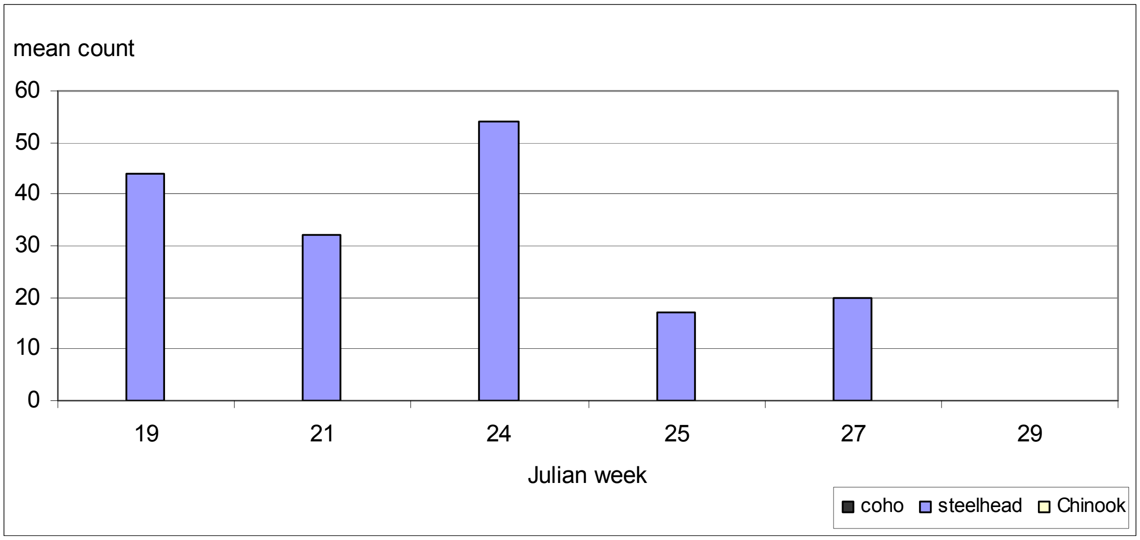


Figure 26. HIG 1: mean number of 0+ salmonids observed per dive count in the Shasta River on Hole in the Ground Ranch in 2008

<u>Kettle Springs Creek</u>

On 08/06/2008, we counted the number of salmonids rearing at the outfall of Kettle Springs (Photo 12). Counts were made by three divers making separate passes through the pool. 0+ coho counts ranged from 23 to 52 (mean = 34), 0+ steelhead counts ranged from 23 – 64 (mean 46). No Chinook were observed.

4.4 PIT Tagging Results

Capture and Tagging

<u>Nelson Ranch (RM 32) Capture and Tagging Effort, Spring/Summer 2008</u>

A total of 1,331 untagged BY2007 coho were captured at the Nelson Ranch from February to July of 2008, of which 509 were implanted with PIT tags. A total of 279 coho were captured with the RST and 97 of these were implanted with PIT tags. A total of 1,052 coho were captured with the fyke nets and 412 of these were implanted with PIT tags. The first BY2007 coho salmon was captured on February 21 and the first was PIT tagged on April 16. See Figure 27 for a summary of Nelson Ranch RST and fyke BY2007 coho catch by Julian week (JW) through the spring and summer of 2008. Recaptures of PIT tagged fish were known whereas recaptures of unmarked fish were likely but not known. See Appendix 10 for total 2008 and 2009 Nelson Ranch salmonid RST and fyke catch data. There was an increase in the number of coho captured in the traps during mid May of 2008 (JW 18). This increase coincided with water temperatures as high as 24˚C and air temperatures in excess of 37˚C. In an effort to reduce mortality associated with handling fish at these high water temperatures, tagging was suspended on 5/17/08 and 5/18/08.

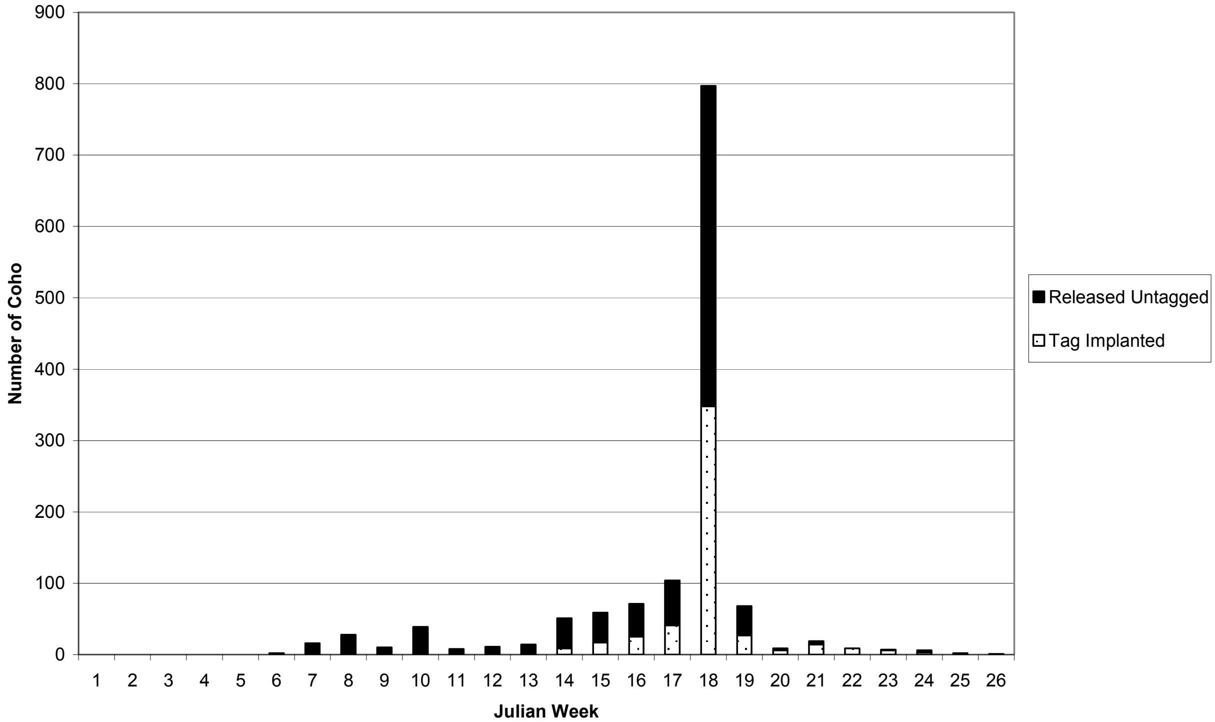


Figure 27. Total BY2007 coho catch at Nelson Ranch (RM 32) with the RST and fyke nets in the spring and early summer of 2008 by julian week.

Quality Control

Of the 84 coho that were tagged and held overnight (approximately 24 hours) as part of the quality control evaluation, one experienced mortality and 83 (98.8%) appeared healthy (exhibiting good swimming behavior and showed no signs of ill effects), and were released back to the river. No shed tags were observed from the 84 holdovers (Appendix 11). Overall, short-term tag loss and tagging mortality did not appear to be significant.

Nelson Ranch (RM 32) Capture and Tagging Effort, Fall 2008, Spring 2009

Intermittent RST and fyke sets during the fall of 2008 resulted in the capture and tagging of 18 BY2007 coho. In the spring of 2009 a total of 16 BY2007 coho were captured and tagged.

Tagging at Rearing Locations

Reconnaissance dives revealed the presence of rearing coho in several areas of the Shasta River and its tributaries during the summer of 2008. Total coho estimates are rough approximations based on opportunistic reconnaissance snorkel surveys throughout the summer of 2008 and are subject to constraints such as water clarity and available cover. Results of capture efforts in these locations are summarized below and are shown in Table 8.

SBS Dive Site 1 (RM 32.9)
In the spring of 2008, an estimated 50 coho were observed rearing at SBS dive site 1 (RM 32.9). 13 of these were captured with the hand net and implanted with PIT tags.

HIG dive sites 1-5 (RM 35.0-36.8)
In the late spring and summer of 2008, snorkel divers observed an estimated 1,000 coho rearing from RM 35 to 36.8. A total of 223 coho salmon were captured and tagged in this reach. Minnow trap and hand net efforts in the spring of 2008 (5/28 to 6/25) from RM 36 to 36.8 resulted in the tagging of 59 coho. Fyke and seine efforts in beaver pond habitats at RM 36 and 36.8 during the fall of 2008 (8/20 to 12/10) resulted in the capture and tagging of 141 coho. Seining efforts in two pool habitats, approximately 100 yards upstream and downstream of HIG dive site 2 (RM 35.2) resulted in the tagging of 23 coho in the fall of 2008.

Big Springs Creek
In the summer of 2008 snorkel divers observed an estimated 200 coho rearing at the outfall of Big Springs Lake and 86 of these fish were captured with a seine and tagged during three occasions in the late summer and fall of 2008 (8/7, 9/8, 11/13). Snorkel divers also observed an estimated 50 coho rearing at a bridge crossing at Big Spring Creek (RM 1.5) in late fall of 2008, of which 23 were captured with a seine and tagged.

Kettle Springs
In the summer of 2008, snorkel divers observed an average of 34 coho rearing at the outfall of Kettle Springs. At this location, seven coho were captured with hand nets and tagged in the late summer and fall of 2008.

Table 8. Results of tagging in rearing locations

Summary of BY2007 Coho Tagging from Rearing Areas in 2008			
Tagging Location	**Coho Tagged**	**Tagging Month**	**Gear**
SBS Dive Site 1 (RM 32.9)	13	4, 5	Hand net
HIG Dive Site 2 Vicinity (RM 35.2)	23	9,10,12	Seine
HIG Dive Site 3 Vicinity (RM 36)	87	5, 6, 11, 12	Hand net, Fyke
HIG Dive Site 5 Vicinity (RM 36.8)	113	6, 8, 9, 10, 12	Seine, Fyke, Minnow trap, Hand net
Big Springs Outfall	87	8, 9, 11	Seine
Big Springs Creek RM 1.5	23	12	Seine, Hand net
Kettle Springs	7	8, 9, 10	Hand net
Total	**236**		

Remote Detection System Performance

Overview
In the early stages of this study, remote PIT tag detection systems were still in developmental stages and their performance during the spring and summer of 2008 was marginal. Improvements in the operational and structural aspects of the systems throughout the study resulted in much greater detection capability at each station. The availability of newly improved equipment, combined with permission to access additional habitat areas further upstream, created opportunities to deploy additional remote detection systems in the fall of 2008. Certain locations

served very well for the application of remote PIT tag detection technology. At other locations the systems did not perform well because of poor site conditions related to channel characteristics (high velocities and deep water), high debris loads of aquatic vegetation, or inadequate access to the sites. Several antenna systems were removed during the study for these reasons, and provided minimal data. Antenna system performance at each station is summarized below. See Appendix 12 for dates of antenna system installation and removal by location. Figure 28 shows locations of antenna systems in the upper Shasta River that provided important data for this study.

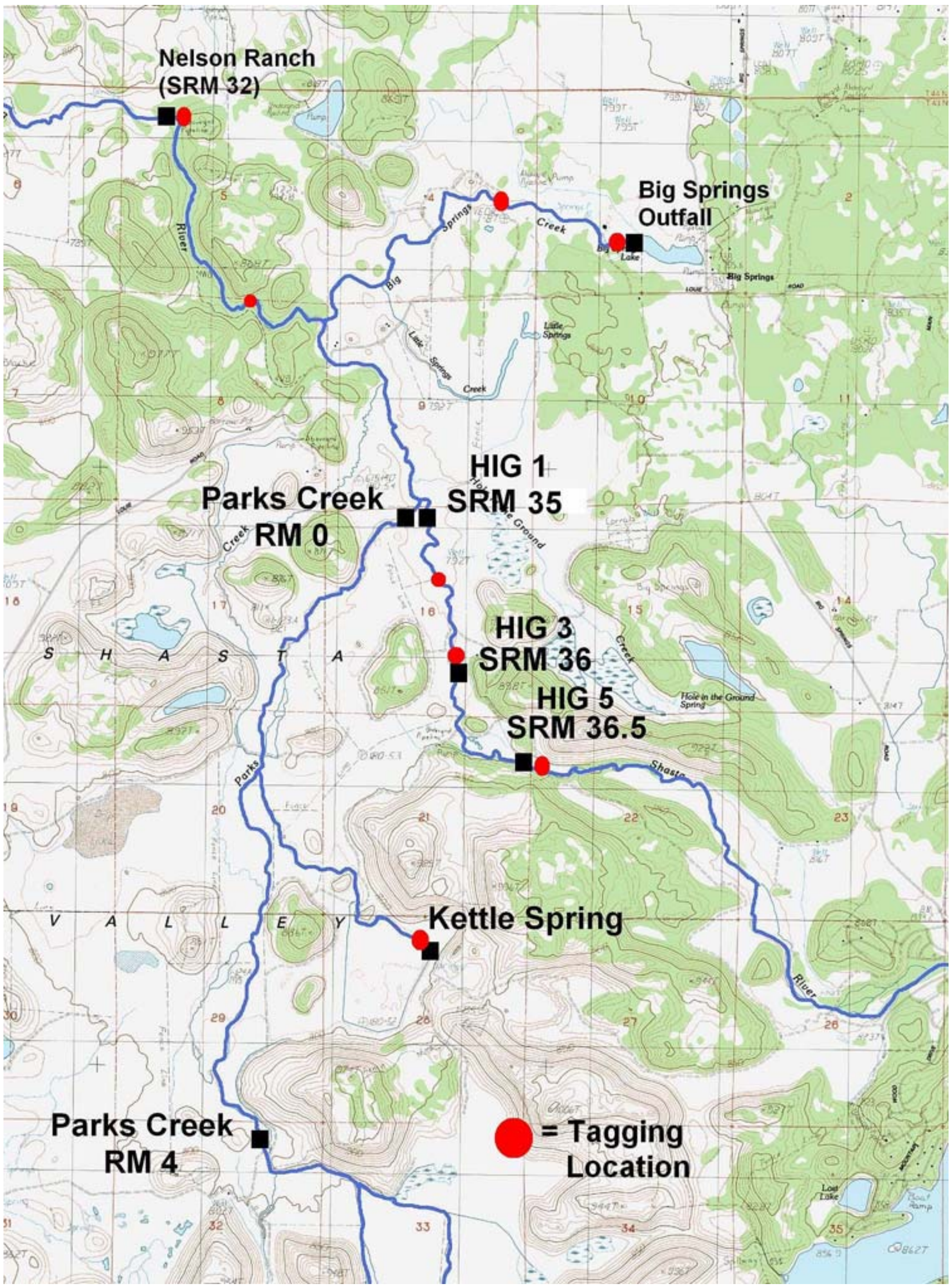


Figure 28. Upper Shasta antenna system locations (SRM = Shasta River Mile)

RM 0 (Mouth of Shasta River)
Detection coverage at the Shasta's mouth was most often an estimated 30% of the river's width throughout 2008, and varied between 0% and 80%. High flow and debris load events in the spring of 2008 caused periods of poor or non operation, as did equipment malfunction and interference amongst antennas. The read range of the antennas was often less than 100% of their field, but with shallow water depth in the summer months, the entire water column could still be covered. Positioning of the antennas was altered several times as flows changed due to deployment of additional and alternate equipment, and to accommodate the installation of the Department's Klamath River Project's (KRP) adult salmonid counting weir in the fall of 2008. This partial and inconsistent coverage continued through to the winter of 2008, when the three-system setup was deployed. At that point coverage of each system increased to about 80% of their river transects, and consistent operation was obtained. This high performance during the spring of 2009 provided key data as tagged coho smolts emigrated from the Shasta.

RM 29, 32.1, SBS 1 (RM 32.9), and Big Springs Creek RM 1.6
These systems were subject to the aforementioned limitations in performance and provided minimal data. They were removed during the study for these reasons as well as to make equipment available for locations of higher priority.

Meamber Ranch (RM 15) and Nelson Ranch (RM 32)
These systems varied widely in their detection capability throughout the study as a result of equipment performance, power station failures, high flow and debris loads. Configuration and number of antennas changed on several occasions, as alternate and additional designs were deployed. These systems operated at least intermittently throughout the entire study and provided some useful data.

HIG 3 (RM 36), HIG 5 (RM 36.8), Big Springs Outfall, and Kettle Springs Outfall
These systems were deployed upon tagging of coho in these locations. They were subject to some limitations, but overall performed consistently throughout the study and provided useful data regarding the identified rearing areas.

HIG 1 (RM 35), Parks Creek RM 0, 4
These systems were installed in the fall of 2008 (Parks RM 4 in winter 2009) and performed well throughout their deployment, providing key data regarding migration timing. The configuration of antennas in these systems allowed for directional detection of individual tagged coho.

Detection of Tagged Coho

Detection of Nelson Ranch (RM 32) Spring/Summer 2008 Tagged Coho
Of the 509 coho tagged in the spring and early summer of 2008 at RM 32, six were encountered at RM 0 later that season (Table 9). Recapture and detection of tagged coho at RM 32 was common throughout the period of tagging in the spring and early summer of 2008. Encounters here virtually ceased though, by mid summer. Forty-eight of the 509 were later encountered at upstream locations (Table 10). Detailed encounter histories for these individuals can be found in Appendix 13. Eighty-one of the 509 were encountered at RM 0 in the spring of 2009 when they left the system as smolts, 51 of which had not been encountered since tagging.

Table 9. Date of BY2007 coho tagging at Nelson Ranch (RM 32) and encounter at RM 0 in the spring and early summer of 2008.

2008 Nelson Ranch (RM 32) Tagged BY2007 Coho Emigrants			
Fork length at Tagging	**Tagging Date**	**RM 0 Encounter Date**	**Size at Recapture**
77	5/16/08	6/18/08	93
68	5/16/08	6/26/08	105
87	5/17/08	5/24/08	NA
67	5/17/08	6/28/08	NA
97	5/19/08	5/24/08	NA
103	6/11/08	6/16/08	109

Table 10. Numbers of Nelson Ranch (RM 32) spring/summer 2008 tagged coho first detected at upstream antenna systems by season. Some individuals are represented more than once.

Season of First Detection	HIG 1 (RM 35)	HIG 3,5 (RM 36,36.8)	Big Springs Outfall	Parks Creek RM 0	Parks Creek RM 4	Kettle Springs Outfall
Spring/Summer 2008		17	4			
Fall/ Winter 2008/2009	13			4		4
Spring 2009				14(downstream)	5	

<u>Detection of Nelson Ranch (RM 32) Fall 2008, Spring 2009 Tagged Coho</u>

Of the 18 coho tagged at the Nelson Ranch site in the fall of 2008, four were later encountered at upstream locations (Appendix 14), and a total of nine were encountered as they left the Shasta in the spring of 2009. Of the 16 coho tagged at the Nelson Ranch site in the spring of 2009, nine were encountered as they left the Shasta in the spring of 2009.

<u>Detection of SBS Dive Site 1 (RM 32.9) Tagged Coho</u>

Performance of the antenna at this location was inconsistent. Of the 13 coho tagged in this location, six were detected by the antenna system, and none were detected there after 5/11/08. One of the 13 was encountered at RM 0 as it left the Shasta in the spring of 2009.

<u>Detection of HIG 3-5 (RM 36-36.8) Tagged Coho</u>

Detection histories of tagged individual coho in this reach that were encountered at least one week after tagging are shown in Appendix 15. Coho tagged in the RM 36-36.8 area were not detected elsewhere until smolt migration began to take place in the late winter of 2009, with the exception of one. Portions of coho from these groups were used for our smolt survival analysis and detection probability estimations which are addressed in later sections. The number of individual coho detected by Julian Week at the HIG 5 antenna system is shown in Figure 29 and at the HIG 3 antenna system in Figure 30. Lack of detections at both sites during Julian Week 53 was a result of power station failures. Of the 113 coho tagged at HIG 5, 28 were encountered at RM 0 when they left the Shasta River as smolts in the spring of 2009, as were 37 of the 87 tagged at HIG 3.

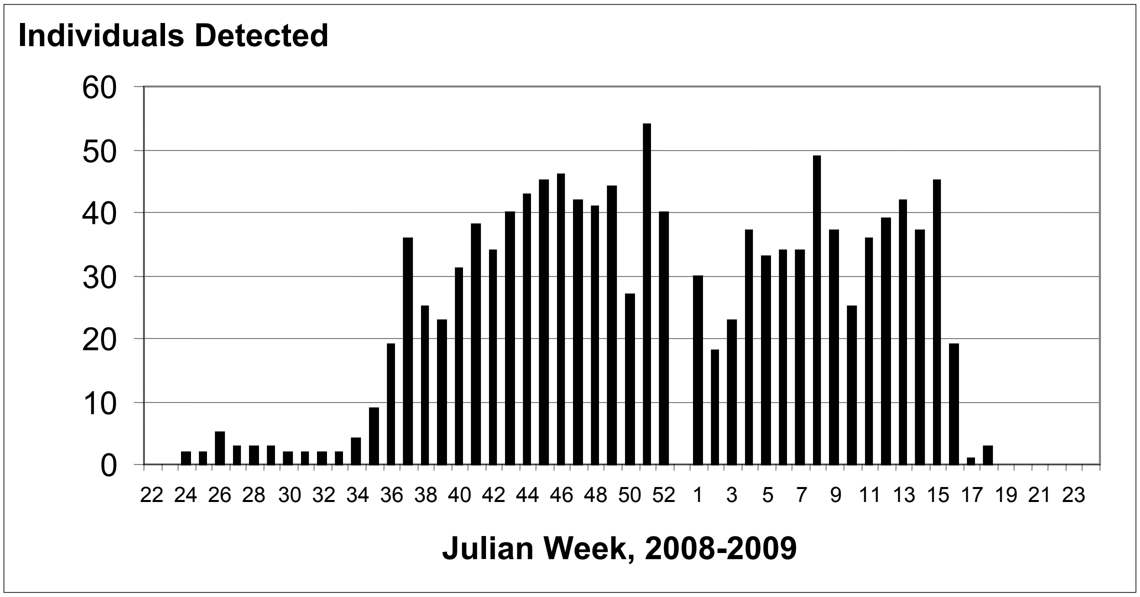


Figure 29. Numbers of individual coho detected at the HIG 5 antenna system by julian week.

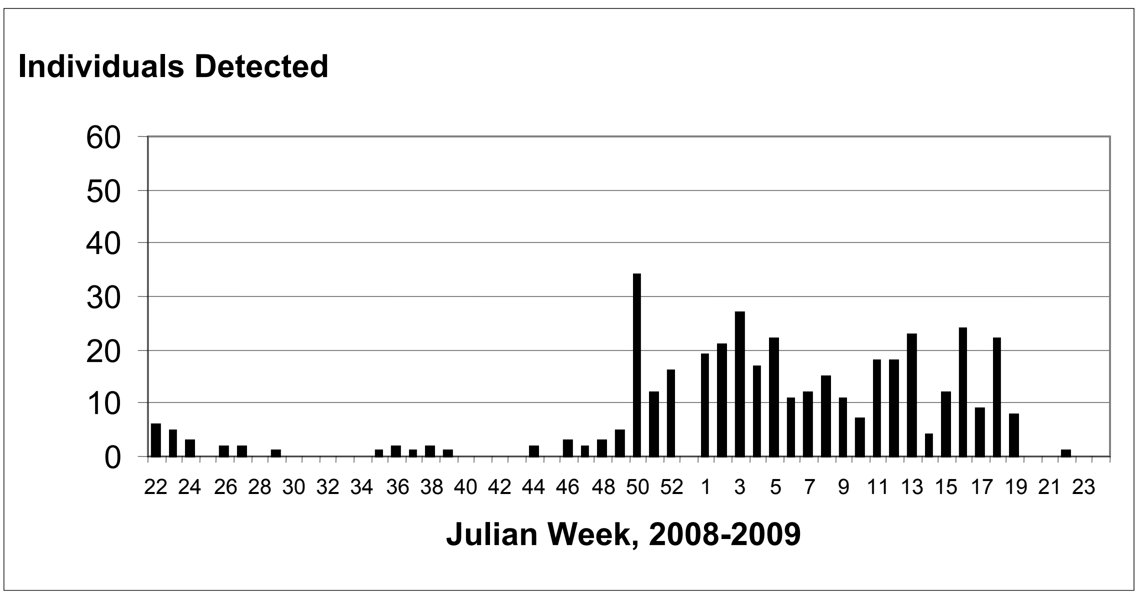


Figure 30. Numbers of individual coho detected at the HIG 3 antenna system by julian week.

<u>Detection of HIG 2 Vicinity (RM 35.2) Tagged Coho</u>

Detection histories of coho tagged at RM 35.2 are shown in Appendix 16, and include three individuals that moved upstream to RM 36 and six that moved up Parks Creek prior to spring 2009 emigration. Of the 23 total coho tagged in this reach, 7 were encountered at RM 0 when they left the Shasta River as smolts in the spring of 2009. A portion of this tagging group was used for survival and detection probability analysis, which are addressed in later sections.

Detection of Big Springs Creek Outfall Tagged Coho

Detection of individual tagged coho from Big Springs outfall by JW at the antenna system there is shown in Figure 31. Spikes in detections in JW 32, 36, and 46 represent the three tagging events. Of the 87 coho tagged at the site, 73 were last detected there in the fall of 2008, nine were last detected there in the winter, and five were last detected there in the spring of 2009. Eight coho that left Big Springs outfall in the fall of 2008 were detected at other antenna systems. Those documented movements are summarized in Table 11. Some individuals are included in more than one category. More detailed detection histories for coho tagged at Big Spring outfall that were encountered at least one month after tagging are displayed in Appendix 17. 32 of the 87 Big Spring outfall tagged coho were encountered at RM 0 when they left the Shasta River as smolts in the spring of 2009.

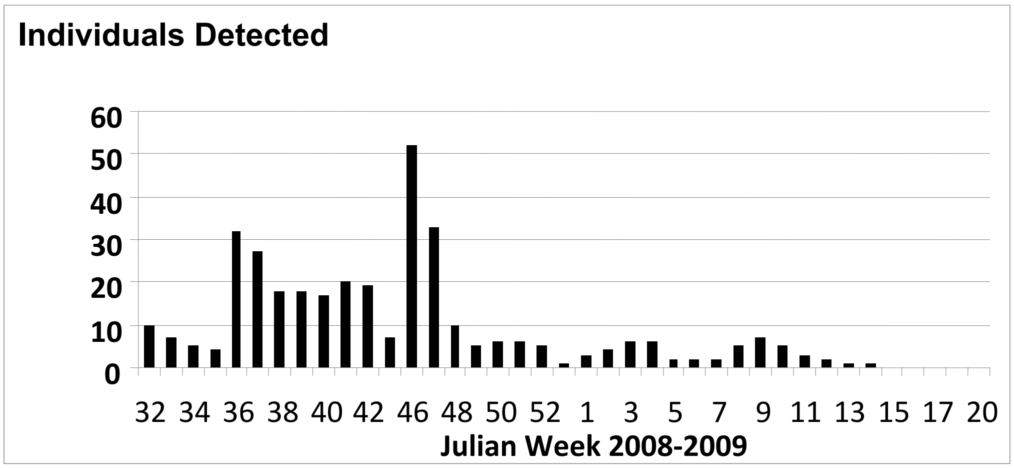


Figure 31. Numbers of individual coho detected at the Big Springs Creek outfall antenna system by julian week in 2008 and 2009.

Table 11. Numbers of Big Springs outfall tagged coho detected at other locations, excluding those in spring 2009 at RM 15 (smolts).

Season of First Detection	RM 15	RM 35	Parks Creek RM 0	Kettle Springs Outfall
Fall 2008				2
Winter 2008/2009	2	2		
Spring 2009	NA		4	

Detection of Big Spring Creek RM 1.5 Tagged Coho

Of the 23 coho tagged at Big Springs Creek RM 1.5, nine were encountered at RM 0 when they left the Shasta River as smolts in the spring of 2009, two of which were also encountered at the Parks Creek RM 0 antenna system. Detection histories for coho tagged at Big Springs RM 1.5 that were later encountered are shown in Appendix 18.

Detection of Kettle Springs Tagged Coho

Tagged coho remained at Kettle Springs until the late fall of 2008, when they were no longer detected at that location. Detection histories of individual tagged coho from Kettle Springs outfall are shown in Appendix 19. Two of the seven Kettle Springs outfall tagged coho were encountered at RM 0 when they left the Shasta River as smolts in the spring of 2009.

Weir 2009 Encounters (RM 0)

Of the 896 total BY2007 coho tagged, 215 were encountered as they emigrated from the Shasta in the spring of 2009 as smolts. Table 12 displays these fish by tagging location with total number tagged at each location, and the expanded estimate based on the detection probability estimates from the next section (point estimates for the two upstream antenna systems and RST multiplied together and subtracted from 1). Timing of RM 0 encounters by day is shown in Figure 32. Growth since tagging of smolts recaptured with the RM 0 RST (by FL) is shown in Appendix 20.

Table 12. Total number of fish tagged by location with number and percentage encountered as they left the Shasta as smolts in the spring of 2009, including expansions based on detection probability estimation of 90.3% at RM 0 during the spring of 2009.

Tag Group	Number Tagged	Encountered at RM 0, 2009	%	Expanded Number Encountered	Expanded %
RM 32 Spring/Summer 2008	509	81	15.91%	88.86	17.00%
Big Springs Outfall	87	32	36.78%	35.10	40.35%
Big Springs Creek RM 1.5	23	9	39.13%	9.87	42.93%
RM 32.9	13	1	7.69%	1.10	8.44%
Kettle Springs	7	2	28.57%	2.19	31.34%
RM 35.2	23	7	30.43%	7.68	33.39%
RM 36	87	37	42.53%	40.59	46.65%
RM 36.8	113	28	24.78%	30.72	27.18%
RM 32 Fall 2008 Tagged	18	9	50.00%	9.87	54.85%
RM 32 Spring 2009 Tagged	16	9	56.25%	9.87	61.71%
Total	896	215	24.00%	235.86	26.32%

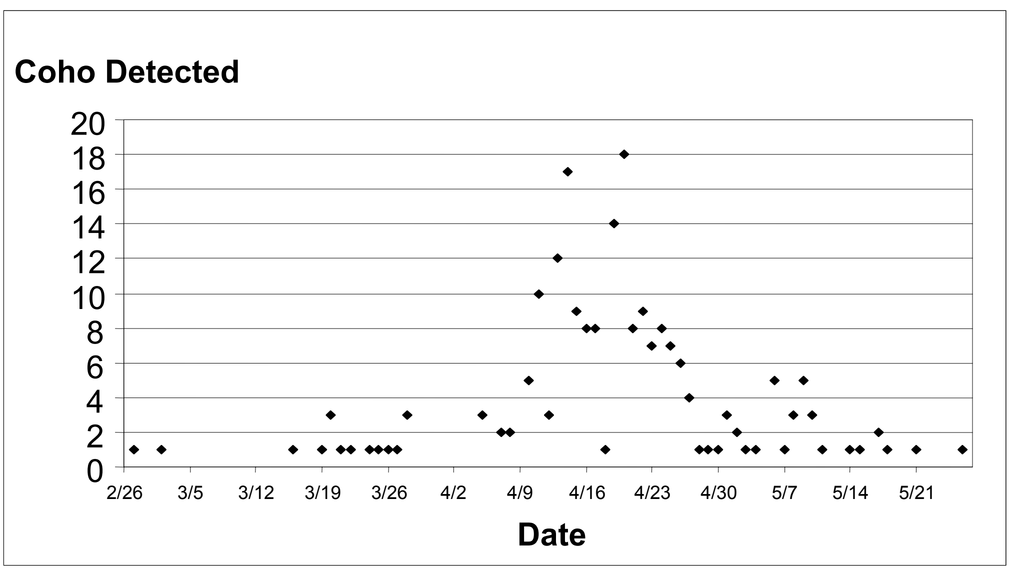


Figure 32. Plot of number of coho detected at RM 0 in spring 2009 by day.

Spring Emigration from HIG

From 3/15/09 to 5/30/09, 80, 51, and 20 coho were first detected at the HIG 5, HIG 3, and HIG 1 antenna system and were used as the first, second, and third release in our survival study. Five candidate models were fitted to the data (Table 13). Based on QAIC*c* values, the best model allowed Φ in reaches 1, 2, and 3 to be different, Φ in reaches 4, 5 and 6 to 1, and all *p* to be different (i.e., our most general model). This model accounted for 51% of the model weight assigned to the candidate models. Model-averaged Φ estimates indicate a substantially lower survival in reaches between HIG 5 and HIG 3 and between HIG 3 and HIG 1 than the reach between HIG 1 and RM 0, given their perspective lengths (Table 14). Model averaged *p* estimates are presented in Table 15, Table 16 summarizes all results, and Figure 33 illustrates the results in a diagram.

Table 13. Akaike's information criterion corrected for small sample size (AIC*c*) and overdispersion (quasilikelihood AIC_c [$QAIC_c$]; overdispersion parameter estimate= 1.54); values were used to select the best model from among five candidate models of survival (Φ) and recapture probability (*p*) for coho smolts emigrating from rearing habitats on HIG, Shasta River from 3/15/09 to 5/30/09 (period symbol = parameter is constant over the given attribute). The best model is presented first: $\Delta QAIC_c$ represents the difference between the $QAIC_c$ value of a model and that of the best model. Akaike weights (w_i) provide a measure of each model's relative weight or likelihood of being the best model in the set given the data. Number of parameters is the total number that is theoretically estimable by the model.

Model	QAICc	$\Delta QAIC_c$	w_i	Number of Parameters	-2log(L)
Φ(reach 1,2,3 different, 4,5,6 fixed to 1.0), p(all different)	520.227	0	0.507	9	772.73
Φ(reach 1,2,3 different 4,5,6 fixed to 1.0), p(3,4,6 are constrained)	521.89	1.66	0.221	7	781.71
Φ(reach 1,2,3 same, 4,5,6 fixed to 1.0), p(all different)	522.251	2.02	0.184	7	782.27
Φ(reach 1,2 same, 3 different, 4,5,6 fixed to 1.0), p(all different)	523.72	3.49	0.088	8	781.33
Φ(.),p(.)	540.055	19.83	0	2	825.48

Table 14. Estimated apparent survival of coho in three Shasta River reaches from 3/15/09 to 5/30/09, including standard error and confidence intervals.

				95% Confidence Interval	
Reach	Reach Length (Miles)	Apparent Survival Φ	Standard Error	Lower	Upper
1 (HIG 5- HIG 3)	0.5	0.844	0.077	0.632	0.944
2 (HIG 3- HIG 1)	1	0.689	0.066	0.547	0.802
3 (HIG 1- RM 0)	35	0.801	0.063	0.648	0.897

Table 15. Estimated detection probability of PIT tag antenna systems and RST from 3/15/09 to 5/30/09.

			95% Confidence Interval	
Detection Location	Detection Probability *p*	Standard Error	Lower	Upper
HIG 3	0.836	0.067	0.663	0.930
HIG 1	0.981	0.022	0.820	0.998
Weir C	0.568	0.085	0.399	0.722
Weir B	0.481	0.068	0.351	0.613
RST	0.358	0.069	0.237	0.501

Table 16. Number of fish released by location, and point estimates of apparent survival (Φ) and detection probability (*p*).

Encounter Locations	HIG 5	Reach 1	HIG 3	Reach 2	HIG 1	Reach 3	WEIR C	Reach 4	WEIR B	Reach 5	RST	Reach 6	WEIR A
Approx Reach Length		.5 miles		1 mile		35 miles		1800 feet		60 feet		120 feet	
Releases	80		51		20								
Φ Estimates		0.844		0.689		0.801		Φ set to 1		Φ set to 1		Φ set to 1	
p Estimates	not estimable		0.836		0.981		0.568		0.481		0.358		not estimable

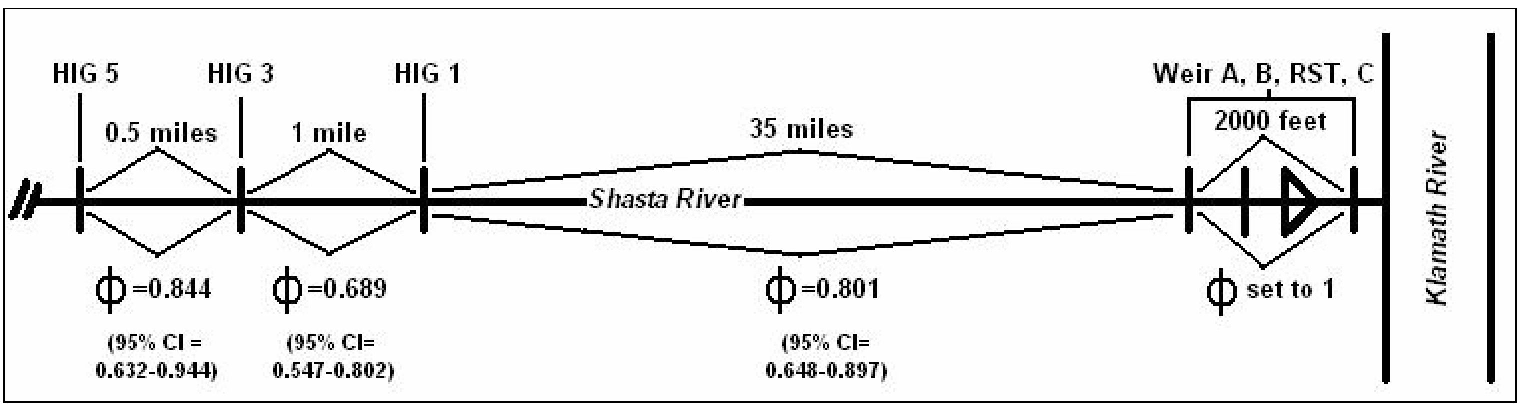


Figure 33. Diagram (not to scale) of encounter locations, reach lengths, and apparent survival estimates, including 95% confidence intervals.

5.0 Discussion

5.1 Water Temperature Monitoring

We observed a number of factors that affected water temperatures within the 4.5 mile section of the Shasta River monitored in 2008 including: periodic releases of water from Lake Shastina, surface diversions at RM 37.4 and 36.1, inflow from cold springs, tailwater return points and inflow from Parks Creek and Big Springs Creek.

Shasta Big Springs Ranch

For four consecutive days in Julian Week 20, 5/16/08 through 5/19/08, the maximum daily water temperatures were greater than 24° C at SBS Sites 1-4. The diurnal change in temperatures of the Shasta River upstream of Big Springs Creek and Big Springs Creek and the Shasta River at SBS sites 1 and 4 during this period are shown in Figure 34. This large diurnal change in temperature was the result of a combination of factors including maximum daily air temperatures over 33 º C, degraded channel condition, a lack of riparian vegetation in Big Springs Creek and flood irrigation (Mount et al. 2009). Because of its shallow depth and lack of shading, flood irrigation water has the potential to warm rapidly during hot weather. Flood irrigation was in full operation on the SBS Ranch on 5/17/08 with tailwater returning to Big Spring Creek (Jeffres 2009). Temperature loggers upstream at HIG 1 and HIG 2 also recorded maximum daily water temperatures over 23° C during this period.

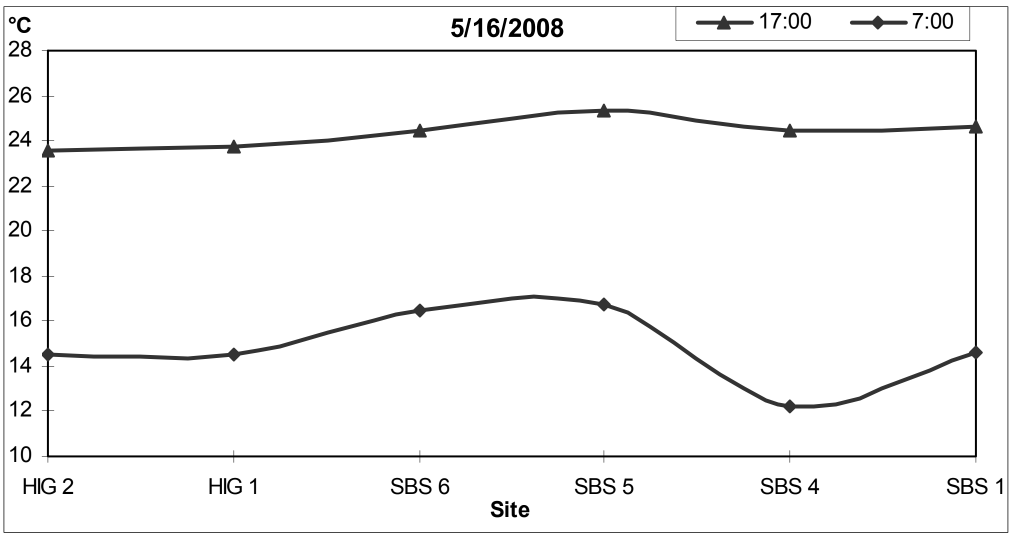


Figure 34. Diurnal temperature change that occurred on 5/16/08 Shasta River between HIG 2 and SBS1

Hole in the Ground Ranch

The highest and lowest MWMT were observed at adjacent monitoring stations, 22.90° C at (RM 37.4) and 13.59 degrees at Clear Springs (RM 37.0). During the irrigation season, water at RM 37.4 is a mix of water that has been stored in Lake Shastina, tailwater from upstream flood irrigation and approximately 2 cfs of 13° C spring water. The stored water from Lake Shastina is delivered via the Shasta River channel for use by irrigators on the upper Shasta River. The MWMT at the Fence site was the highest of any measured in this study (27.09° C). Water from Clear Springs was a constant 13.6° C. Water at HIG Site 5 is a mix of these two water sources. This cold water reduced the MWMT at site 5 by 6.22 degrees from the MMWT at the Fence line site: 26.80 to 20.57, respectively.

Increase in water temperatures downstream of HIG 5

We observed an increasing trend in the MWMTs, the number of days that the maximum water temperatures were greater or equal to 23° C and the maximum diurnal temperature change at sites downstream of HIG 5. There were changes in the location of the weekly maximum temperatures downstream of Clear Springs including periodic spikes in water temperature up to 27º C at HIG sites 1 through 3, (RM 35.2 through 36.3). These were localized events, as shown in the sequence of graphs at four hour intervals on 7/16/08 (Figure 14). Although HIG 2 is only 0.1 miles upstream of HIG 1, it did not show a similar increase in temperature on 7/16/08. The spike in temperature at HIG 1 does not appear to be the result of warm water moving downstream from an upstream location. The elevated water temperature events occurred for a short period of time, typically for two or three days. The characteristics of these abrupt increases in water temperatures suggest that they were caused by warm water entering the river at specific points.

Figures 35 and 36 are aerial photos that show Light Detection and Ranging (LIDAR)-generated tailwater neighborhoods for the irrigated pastures along the Shasta River from HIG Sites 1-5.

LIDAR is similar to RADAR but uses laser pulses as opposed to radio waves. By measuring the time taken for an emitted laser pulse to reach an object and reflect back to a receiving detector, the distance to an object may be determined. If the exact location of the detector is known and this is combined with multiple ranges to a specific object, a three dimensional image of the object, or terrain, can be visualized. In this case, an aircraft equipped with a laser coupled with navigational systems emits laser pulses hundreds of times each second over a swath of terrain. The laser scans the terrain, and when this data is combined with the navigational and positional data of the aircraft, detailed coordinates of the surveyed terrain are generated. All data is collected and delivered in a digital format. The data can easily be imported into a number of GIS programs for further analysis. The data points consist of x, y and z coordinates that can be used in GIS programs to produce digital elevation models (DEM) that can be used to make highly detailed terrain surface models. These models can be coupled with aerial images to make orthomaps.

In January 2008, Terrapoint LLC conducted LIDAR flights along the length of the Shasta River as well as major tributaries for the Shasta Valley Resource Conservation District (SVRCD). Terrain surface models and orthomaps were generated for the purpose of determining tailwater pour points and corresponding tailwater watersheds or neighborhoods.

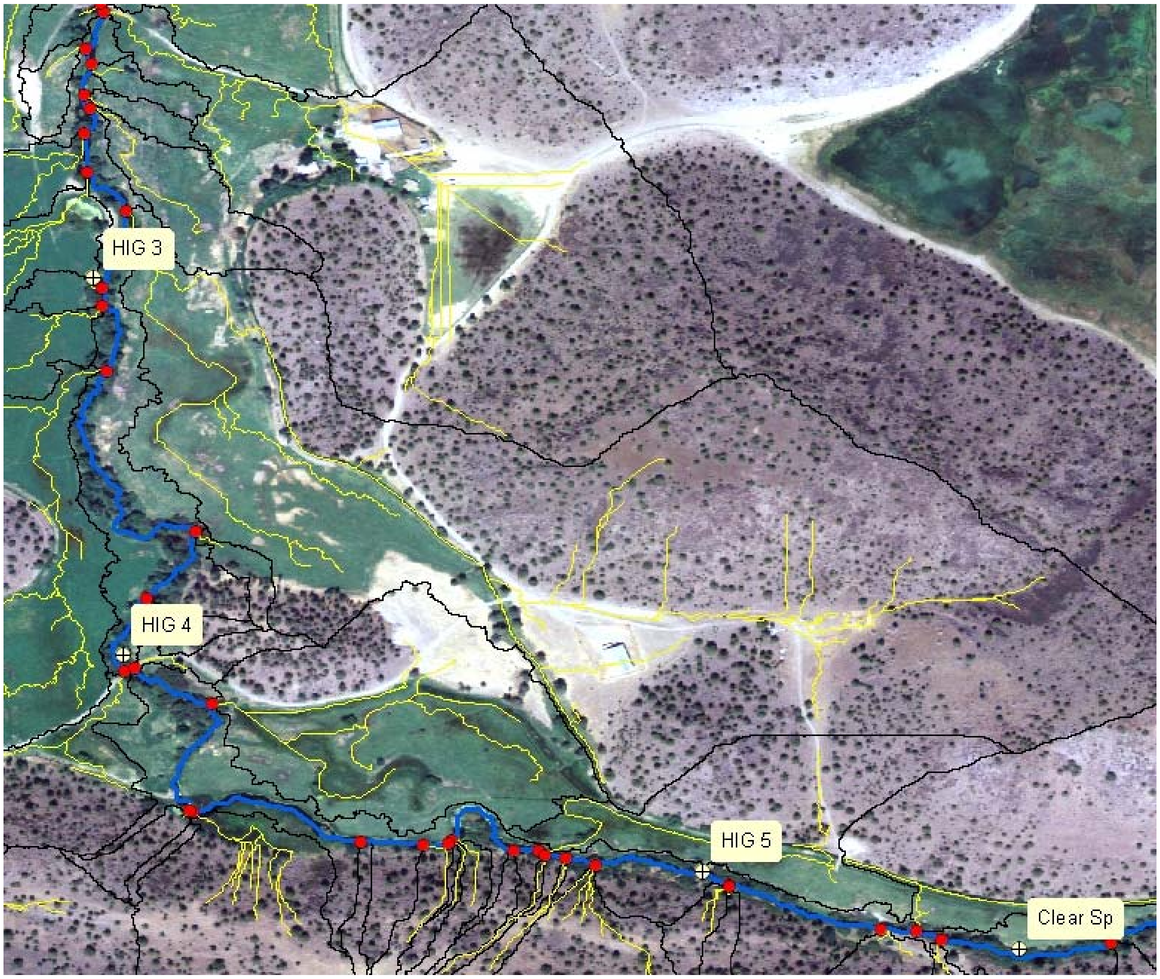


Figure 35. LIDAR generated tailwater neighborhoods and pour points for HIG sites 3, 4 and 5

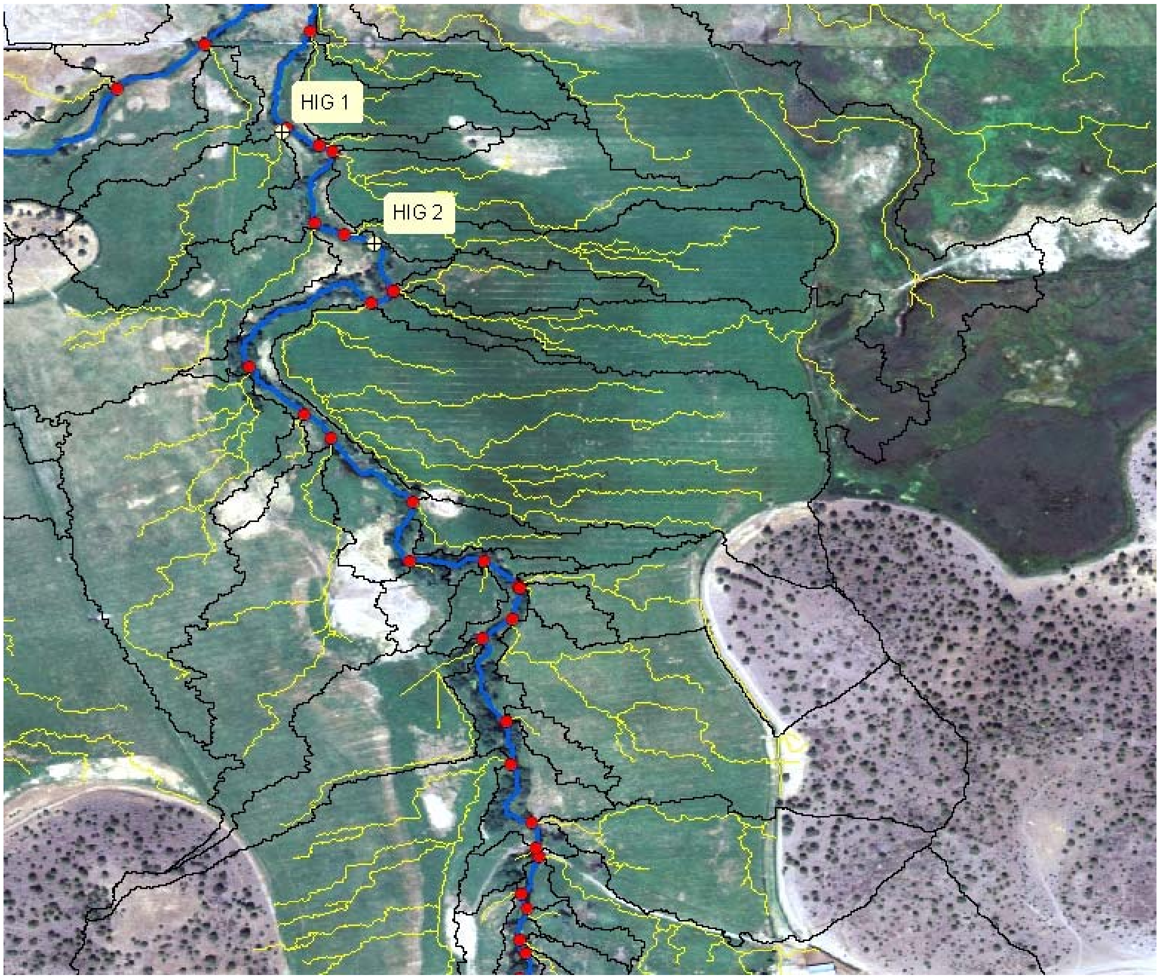


Figure 36. LIDAR generated tailwater neighborhoods and pour points for HIG sites 1 and 2.

In Figures 35 and 36, the individual neighborhoods are outlined in black and the pour points are indicated as red dots. The neighborhoods in Figures 35 and 36 include drainage from entirely non irrigated terrain as in the upslope area at the bottom of Figure 35 and from neighborhoods that include upslope area as well as irrigated pasture. Some of the neighborhoods include only irrigated pasture. The orthomaps show topographic features and the location of pour points if water was applied to the neighborhoods. We believe that water temperatures were warmer and less stable at HIG 1 and HIG 2 due in part to the effects of irrigation tailwater returning to the Shasta River. The date, duration, quantity and temperature of tailwater returning at the pour points are needed to determine the specific effects of tailwater within this reach.

5.2 Flow Monitoring

Hole in the Ground Ranch

The short sampling period and limited access resulted in a small number of daily in-stream flow calculations (5 or 6 calculations per site). Measurements on June 11th, July 8th and July 21st provided the most useful data for comparison because mainstem flow transects were measured at all five sites on the same day. Although simultaneous measurements of discharge at all five transects would be preferable, we believe the discharge calculated accurately depicts hydrological trends at the monitoring sites during the sampling period.

The highest mean discharge was measured at the farthest upstream transect, HIG 5 (mean =7.25cfs, n=5). The lowest calculated discharge varied by day between sites HIG 4 and HIG 3 (Appendix 7); but mean discharge at HIG 3 was lowest and the least variable (1.30 cfs, n=5, δ=0.23). Discharge at sites HIG 2 and HIG 1 was moderate in comparison to the upstream sites (Appendix 7); with the exception of July 8th when discharge was greatest at HIG 1 (6.36cfs). Direct observation of diversion locations and points of tailwater return suggest the low rates of discharge at sites HIG 4 and HIG 3 are due, at least in part, to water removed from the channel at the cone-screen diversion. Likewise, we attribute the rebound in discharge witnessed at downstream sites HIG 2 and HIG 1 as due, at least in part, to tailwater returning to the river from water diverted at the cone-screen or upper diversions. Additional monitoring as well as information such as dates and quantities of water diversions, locations and duration of flood irrigation, and exact locations of all tailwater return locations would be necessary to make more definitive statements on area hydrology.

5.3 <u>Direct Observation</u>

Coho distribution and river temperatures

<u>Spring distribution</u>

In April of 2008, we observed 0+ coho rearing in suitable habitat throughout the SBS study reach (RM 32.9 – 33.6). Figure 37 shows the temperature conditions at SBS 1 during the last week of April 2008. The highest recorded temperature at SBS 1 typically occurred at 1700 hours. The temperature at 1700 during the last week of April ranged from 17.08 to 21.46 with 75% of the records being less than or equal to 20.98.

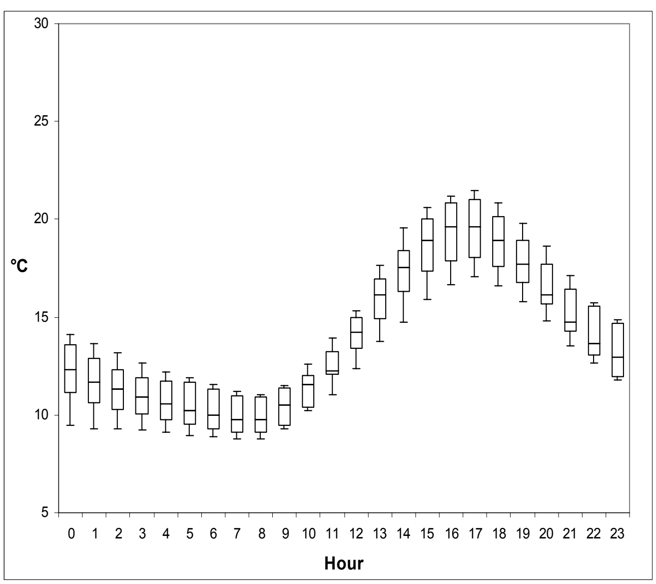


Figure 37. SBS 1 Hourly Water Temperature Variability for April

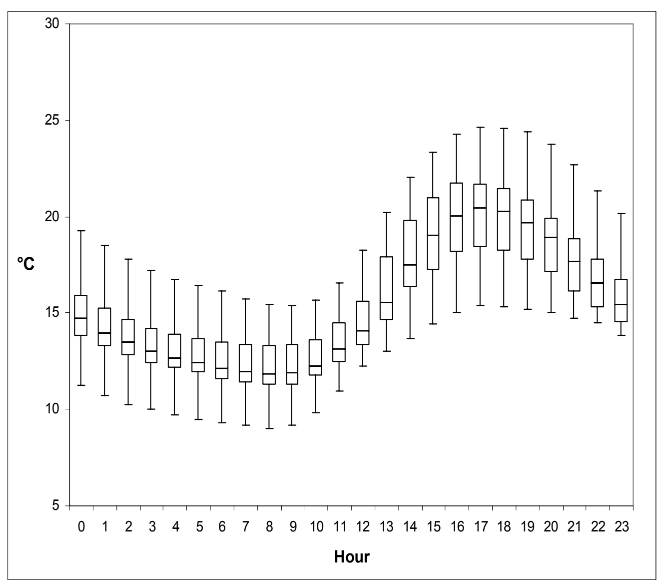


Figure 38. SBS 1 Hourly Water Temperature Variability for May

Spring 2008 migration

As air temperatures rose in mid May, so did the water temperatures at the monitoring sites on the Shasta River. During May, water temperature at SBS 1 at 1700 hours ranged from 15.36 to 24.6 degrees C, with 75% of the records being less than or equal to 21.68 (Figure 38). From 5/16/09 through 5/19/09 the daily maximum water temperatures at SBS 1 were over 24 degrees. The last observation of coho at SBS 1 was on 5/21/09.

In mid May some of the coho tagged at the Nelson Ranch RM (32) moved upstream and showed a preference for the conditions at HIG 3 over HIG 2. Figure 39 shows the temperature conditions at HIG Site 2 for 5/14/08 through 5/31/08. During this period water temperatures ranged from 14.96 to 23.32 degrees C. At 1700, 75% of the records were less than or equal to 22.13. Figure 40 shows the temperature conditions at HIG Site 3 during the same period. The warmest water at this site was recorded at 1600. Water temperatures ranged from 13.76 to 20.43 with 75% of the records less than or equal to 16.12 degrees.

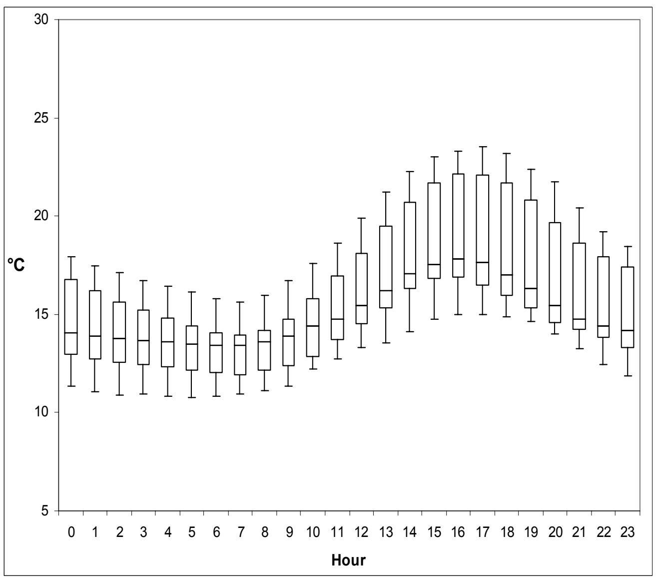


Figure 39. HIG 2 Hourly Water Temperature Variability for May

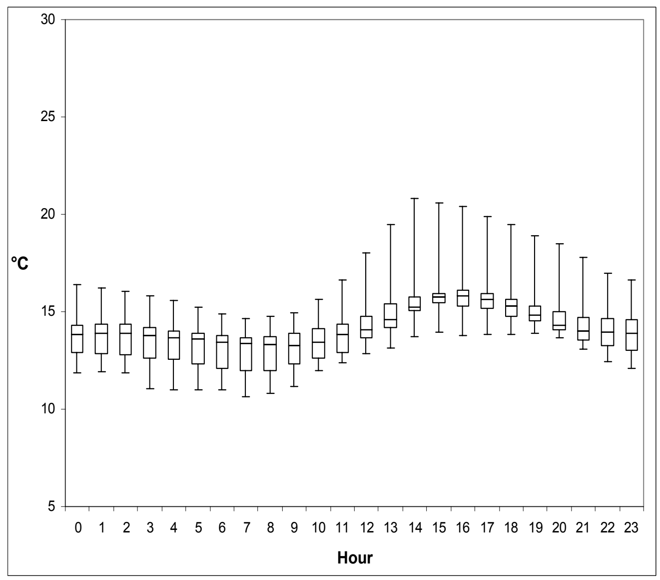


Figure 40. HIG 3 Hourly Water Temperature Variability for May

It appears that the displacement of coho from SBS 1, 2 and 3 in May was the result of a short term spike in the maximum daily water temperatures rather than differences in temperatures from the 25th to 75th percentile. Maximum daily water temperatures at SBS 1 increased from 21.46 in April to 24.60 in May. This increase of over 3° C in the maximum daily temperatures occurred for four days consecutive days. The difference in the 75th percentile, between April (20.98) and May (21.68) was only 0.7° C. indicating that for the majority of the time, temperature conditions at SBS 1 were similar in April and May.

During May 2008, the most apparent difference in water temperature conditions between HIG 3 where coho reared and HIG 2 where they did not, is the temperature of the 75th percentile, 16.12° C and 22.13° C respectively. This is a surprising difference in that HIG 2 and HIG 3 are only 0.8 miles apart and indicates that significant thermal loading occurred between HIG 2 and 3.

A study of the effects of water temperature on juvenile coho in Redwood Creek determined that stream temperatures appeared to be a dominant factor in controlling their distribution (Madej et al. 2006). In this study, juvenile coho were not found in stream reaches where the MWMT ranged from 23 to 27° C. Other effects of elevated water temperatures on juvenile coho include significant decreases in swimming speed at temperatures greater than 20° C (Griffiths and Alderice1972) and cessation growth at temperatures over 20.3° C (Bell 1973).

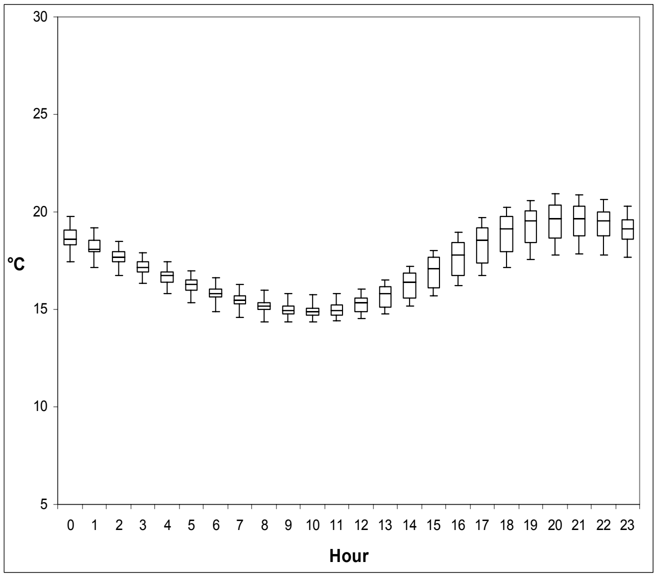


Figure 41. SBS 1 Hourly Water Temperature Variability for July

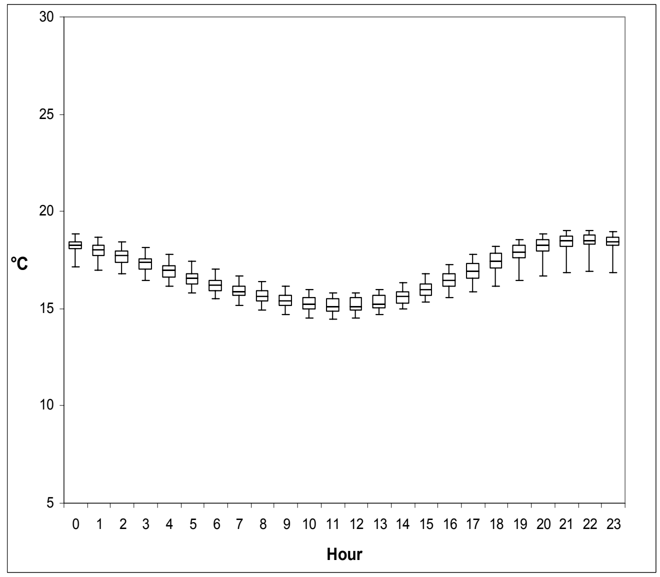


Figure 42. SBS 1 Hourly Water Temperature Variability for August

Prior to the increased water temperatures in mid-May, we noticed that rearing coho were associated with velocity shelters and cover provided by water birch trees and woody debris. These habitat elements were still present and functioning after water temperatures increased and coho were displaced. Whisker plots for July and August at SBS1 were surprisingly cool (Figures 41 and 42). Although temperatures in July and August were cooler than temperatures in April, coho did not return to the rearing habitat at the SBS sites 1, 3 and 4. Hourly water temperature variability at all sites for the season are shown in Appendix 6.

Summer 2008 Distribution of Coho

All of the locations in which we found coho rearing over the summer in 2008 were associated with cold springs including the pool at the outfall of Big Springs Lake, a 1.02mile reach of the Shasta River downstream of Clear Springs HIG sites 5, 4, and 3. Juvenile coho were also observed rearing during the summer in Kettle Springs Creek at the outfall of Kettle Springs, in Big Springs Creek at outfall of Big Springs Lake and at a small coldwater seep on the mainstem Shasta River at River Mile 33.3.

HIG 5 had the best rearing habitat for juvenile coho of any site in the Shasta River mainstem study reach. Features included an abundance of woody debris and vegetation for cover, and a nearly complete canopy cover over the river of water birch and alder trees. An abandoned Beaver dam 350 feet downstream of HIG 5 has created a pool over 500 feet long. Water velocities were slow enough for the fish to easily hold their position in the channel while food drifted to them. Because the site is directly downstream of Clear Springs, it had the lowest MWMT of all of the mainstem sites (20.52° C).

5.4 **PIT Tagging Discussion**

Nelson Ranch Tagged Coho

An initial movement of BY 2007 coho fry was documented by an increase in their catch at the Nelson Ranch traps (RM 32) in mid May of 2008. The origin of these captured coho is not known. Of the coho tagged with this effort that were again recaptured or remotely detected, one group left the Shasta River as 0+ that same season, while a second group migrated to upstream habitats. Poor detection capability and lack of system deployment at key locations during the spring and summer of 2008 made the size of these groups difficult to identify with confidence. Detections of individuals from this group in the fall and winter of 2008 and 2009 at Parks Creek RM 0, 4, Kettle Springs, and RM 34.9 suggests that there was redistribution of coho during the fall. A third group of these tagged coho was not encountered again until they left the Shasta River as smolts in 2009. With increased detection capability at RM 0 at that time, the number encountered there likely reflects a more accurate estimate of the number of individuals in this group. These data suggests that other cold water summer rearing habitats exist that were not monitored during this study. Possible locations include Bridge Field Spring, a tributary to Parks Creek, lower areas of Big Springs Creek, and other areas on the main stem Shasta River.

HIG Tagged Coho

Coho had already colonized HIG (RM 34.5-36.8) when the first reconnaissance dives took place there in the spring of 2008. It is not known whether successful coho spawning seeded this reach directly or if all coho present migrated there from other locations. Encounters of individuals here that were tagged at Nelson Ranch (RM 32) indicate that at least a portion of the population migrated there from other locations. Coho tagged in the HIG 3-5 (RM 36-36.8) area tended to remain there until smolt migration took place in the spring of 2009. This habitat was associated with abundant woody debris and macrophyte cover in contrast with the other identified summer rearing areas. Two beaver dam impoundments also existed in this reach during the study. The first, located below HIG 5 (RM 36.8), was in place upon first access to the property and appeared abandoned throughout the study. The second, located below HIG 3 (RM 36) was erected in the fall of 2008, and drastically altered the habitat for several hundred yards upstream of it. What had existed as riffle-pool type habitat with marginal woody debris became pond type habitat with submerged woody debris. Coho were observed in schools of approximately 20 to 100 throughout the fall and winter of 2008/2009 in these pond habitats.

Spring Emigration from HIG

Based on detection data, coho smolt survival was lowest on the HIG reaches of the main stem Shasta River. This is a significant loss considering the population status of Shasta River coho and the limited number of locations where coho are able to successfully rear from fry to smolt. The additive effect of these low survival rates are especially significant to populations migrating from areas high in the watershed. For example, if the point estimates are applied to 100 coho smolts emigrating from the HIG 5 area, that number is reduced to 84 by the time they reach HIG 3, 58 by HIG 1, and 46 by the time they reach the Shasta River's mouth. The temporal trend in detections of coho from the first and second releases at HIG 1 indicates that successful emigration peaked from approximately 4/20/09 to 5/10/09 (Figure 43). The date of last detection of individuals from the first and second releases not detected at HIG 1 appears to be correlated with successful emigration, suggesting that mortality may have been tied to movement. Though the specific source of these mortalities is not known, we have identified several potential factors based on observations during the spring of 2009. These include low flow conditions, elevated water temperatures, predation and physical barriers to emigration, all of which may be linked or compounded by each other.

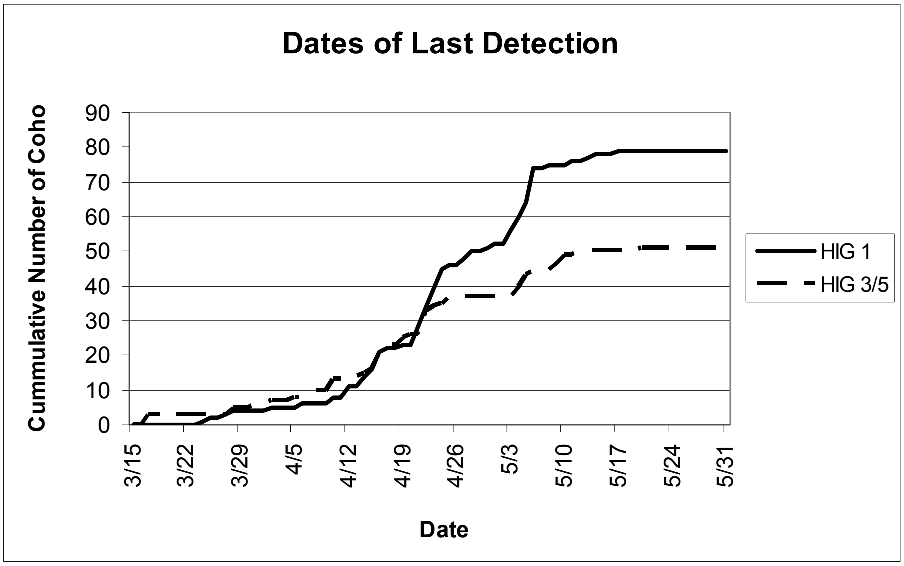


Figure 43. Cumulative numbers of coho from the first and second releases that were detected at HIG 1 (successful HIG emigrants, solid line) and last detected at HIG 3 or 5 antenna systems, not detected at HIG 1 (suspected HIG mortalities, broken line).

The effects of low flow due to irrigation practices on HIG were documented in 2008, and were observed again during the spring of 2009. The stage height of the impoundment at HIG 3 dropped approximately six inches once irrigation season began, and observed flows in the channel below the beaver dams were low relative to before the start of irrigation season (Photo 7, 20, 21). The water temperatures encountered by smolts emigrating through sites HIG 4, HIG 3 and HIG 2 from 3/15/09 through 5/31/09 are shown in Figures 44, 45 and 46. The beaver dam at HIG 3 had a beneficial effect on water temperature. Temperatures were more stable and remained for most of the period in the optimal 10 to 15° C range.

The construction of Dwinnell dam changed the historic hydrograph of the Shasta River. The dam has eliminated freshets that historically would have scoured and replaced spawning gravels, breached beaver dams and assisted fish passage. Smolt emigration is further compounded by reduced flow due to diversions.

Water quality within the ponds may have also been adverse for coho smolt survival. Dense algal blooms were observed in the HIG 3 impoundment on several occasions during the spring of 2009. Potential predators of coho including blue heron, cormorant, kingfisher, common merganser, largemouth bass and otter were also observed. Considering the low sample size and small population, predation may have an influence on both estimated and true survival;

especially when low flows and the migratory behavior of coho during the spring may make them more vulnerable.

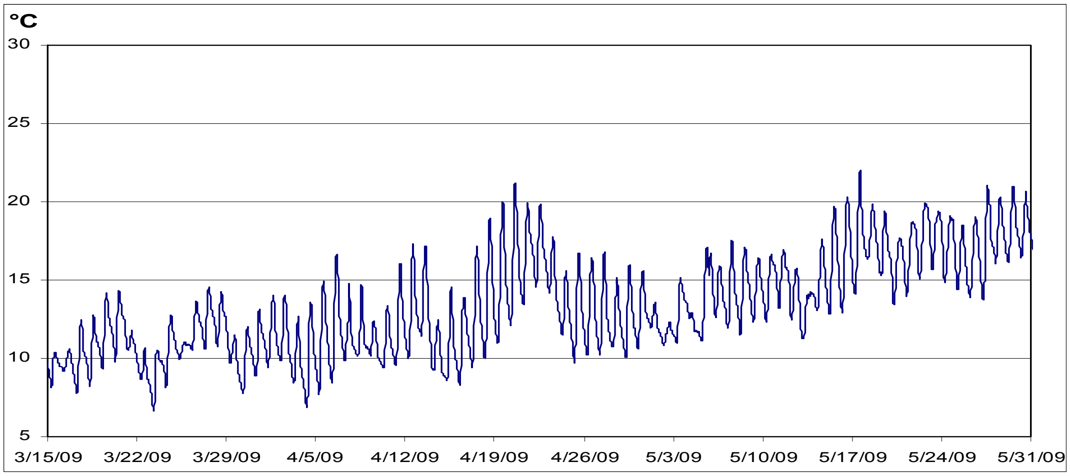


Figure 44. Hourly water temperatures at HIG 4, 3/15/09 through 5/31/09

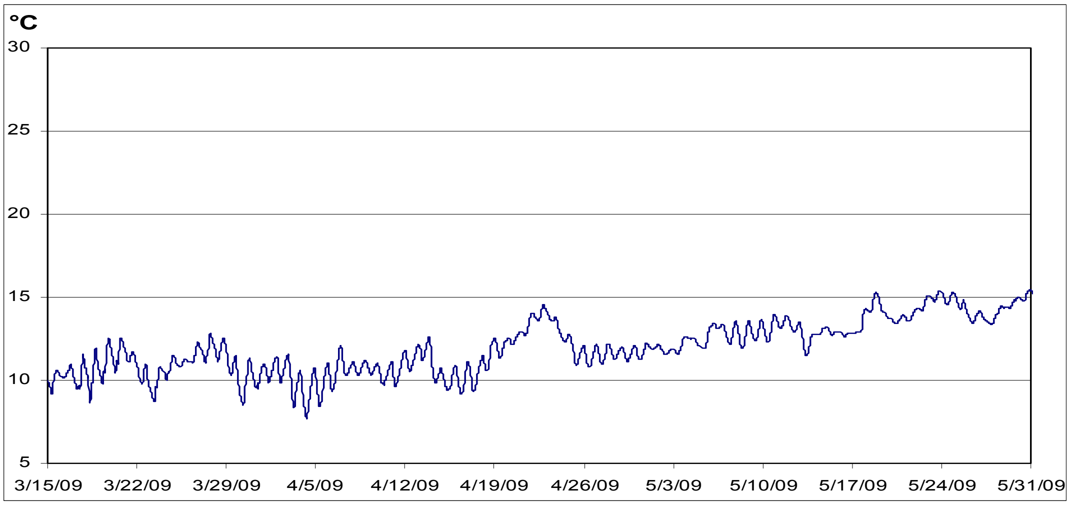


Figure 45. Hourly water temperatures at HIG 3, 3/15/09 through 5/31/09

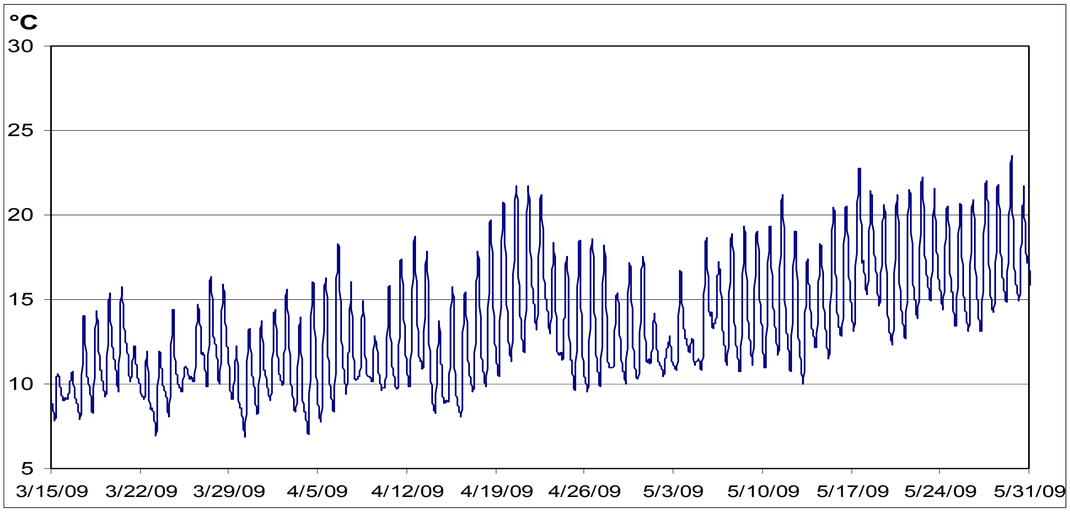


Figure 46. Hourly water temperatures at HIG 2, 3/15/09 through 5/31/09

Photo 20, HIG 5 Impoundment, 4/21/2009

Photo 21, HIG 3 Impoundment, 4/21/2009

Big Springs Outfall (BSOF) Tagged Coho

Coho moved into the pool at the outfall of Big Springs Lake in mid May 2008 (Jeffres, 2009). Individuals tagged at the Nelson Ranch (RM 32) were detected among these fish. The number of tagged individuals detected at the outfall declined rapidly in December of 2008. A portion of these were encountered at upstream as well as downstream locations in the fall and winter of 2008.

Kettle Springs Tagged Coho

Though the number of individuals tagged and their detection histories are sparse, PIT tag detection data at Kettle Springs suggests that coho migrated to the area in summer of 2008 and redistributed to and from the area in fall and winter.

RM 35.2 and Big Springs Creek RM 1.5 Tagged Coho

A portion of the coho tagged in the HIG 2 (RM 35.2) area exhibited a fall/winter redistribution behavior, unlike tagged coho upstream of the beaver dam at HIG 3 (RM 36). Coho tagged at Big

Springs RM 1.5 were also detected at other locations shortly after tagging, again demonstrating a fall/winter redistribution.

6.0 Summary

As water temperatures warmed in May of 2008, we saw 0+ coho migrate upstream to sites cooled by spring inflow. Coho remained at these locations until temperatures cooled in the fall or until they emigrated as smolts. With this life history tactic, Shasta River coho are well adapted to the hot summers typical in eastern part of the ESU. Due to the cold springs, there is great potential for improving and increasing the amount of rearing habitat and coho production in the Big Springs Complex.

Based on the number of adults returning in 2008 and 2009, the observed juvenile production in 2008 and the projected smolt to adult survival, we expect that Cohorts A and C will continue to decline and are functionally extinct (Table 17). Cohort B is the last remaining cohort with viable numbers of adults projected to return. We estimate that 5,000, 1+ coho emigrated from the Shasta River in 2009. If smolt to adult survival is average at 2.9%, we expect that 148 adults will return in the fall of 2010.

Table 17. Status of Shasta River coho cohorts

Cohort/ Brood Year	Number of Returning Adults	Number of known redds in Big Spring complex	Juveniles observed at summer rearing habitat
Cohort C BY 2008	31	2	14
Cohort A BY 2009	As of 12/16/09; 9males	0	NA
Cohort B BY 2010	148 projected for 2010	NA	NA

While the present trend for all cohorts is downward, between 2001 and 2004 there was a 28% increase in the size of Cohort B (Table 2). This occurred due to an increase in the number of smolts produced per adult and higher than average smolt to adult survival. Factors limiting smolt production and survival in the natal stream have been discussed in this report. These factors can be effectively addressed through established stream restoration techniques and alternative land use practices.

Over-summer cold water rearing habitat is essential to smolt survival. Critical rearing habitat on the Shasta Big Springs Ranch is currently undergoing restoration. Efforts by the TNC are producing rapid improvements in water temperature and stream conditions. In the summer of 2008, over 70% of the juvenile coho observed rearing in the Shasta River were found on EII properties (Chesney, 8/2008 power point). During the summer of 2009, EII properties were the only known location in the Shasta River where coho reared (Kettle Springs field note 2009). Restoration efforts similar to TNC's are needed quickly on EII properties to prepare for the return of BY 2010.

As of December 2009, we have identified habitat conditions and land use practices in the Big Springs Complex that if left unchanged will likely reduce the production and survival of juvenile coho from BY 2010. These include:

1. Limited access for adults to spawning habitat due to low streamflow and barriers to upstream migration (October 15th through December 15th).

2. Destruction of redds by cattle in the channel and riparian areas.

3. Limited access for juveniles migrating to summer rearing habitat due to reduced flows and elevated water temperatures caused by the diversion of spring water and tailwater returning to the stream (March 1 through June 30th).

4. Reduced habitat at cold water refugial areas during the summer due to diversion of spring water and warm tailwater returning to the stream (March 1 through September 30th).

5. Warming of cold water refugial areas by the release of warm water from Lake Shastina (May 1 through September 15th).

6. Reduced survival of emigrating smolts due to low flows and increased water temperatures due to diversions and tailwater returning to the stream (March 15th through May 31st).

7.0 Recommendations

Due to the large amount of privately owned land in the Shasta Valley, it is essential that land owners and resource management agencies and organizations work together to implement solutions such as those outlined in Table 18.

Table 18. Observed concerns, life stage affected, location and example solutions for maximizing salmon production and survival in the upper Shasta Watershed on the Hole in the Ground and Shasta Springs Ranches

	Concern	Life stage impacted	Location observed	Dates	Example solutions
1	Redds and egg viability impacted by livestock in the channel	Spawning and incubation	Parks Cr., Shasta Springs Ranch Shasta River, Hole in the Ground Ranch	10/15 - 4/30	• Exclude livestock from stream
2	Poor adult fish passage due to instream barriers	Spawning	Shasta River, Hole in the Ground Ranch	10/15 – 12/15	• Modify downed willows in stream for improved access
3	Poor adult fish passage due to low flows	Spawning	Shasta River, Hole in the Ground Ranch	10/15 – 12/15	• Release / bypass water from upstream sources
4	Elevated water temperatures and fine sediment due to tailwater return to the stream	Rearing	Shasta River, Hole in the Ground Ranch Parks Cr., Shasta Springs Ranch Kettle Springs Creek, Shasta Springs Ranch	3/1- 9/30	• Improve efficiency of applied irrigation water to reduce tailwater • Tailwater capture/reuse
5	Reduced rearing habitat due to low flows resulting from diversion of cold spring water	Rearing	Shasta River, Hole in the Ground Kettle Springs Creek, Shasta Springs Ranch	3/1 – 9/30	• Minimize use of cold spring water for irrigation • Keep adequate water quantity and quality instream to maintain fish in good condition
6	Access to cold water refugia limited by diversion structures, instream barriers and low flows due to diversions	Juvenile migration	Shasta River, Hole in the Ground Ranch Kettle Springs Creek, Shasta Springs Ranch Bridge Field Springs, Shasta Springs Ranch	3/1 – 6/30	• Improve fish passage where needed • Maintain sufficient water quality and quantity to provide access to rearing areas
7	Reduced smolt survival during emigration due to low flow and high water temperatures resulting from diversion and tailwater return	Smolt emigration	Shasta River, Hole in the Ground Ranch	3/1 – 6/30	• Maintain sufficient flows and suitable temperatures to allow fish passage out of rearing habitat

Monitoring Recommendations

Continue to work with landowners to implement monitoring tasks identified below in 2010/2011/2012

- Spring- Summer 2010;
  Using the water temperature and coho distribution information collected in 2008 and 2009 as a guideline (Section 5.3), we recommend that water management strategies be developed and tested to conserve cold water at critical over summer rearing habitat and increase rearing areas with suitable water temperatures for coho.

- Fall 2010
  Determine the location of spawning in fall 2010 by completing comprehensive spawning ground surveys

- Spring / Summer 2011
  Implement practices developed in 2010 to conserve cold water rearing habitat in the spring and summer of 2011

- Monitor distribution of rearing and conditions of habitat in the spring and summer of 2011

- Apply PIT tags and deploy antenna network to monitor migration and estimate the probability of survival of rearing parr

- Spring 2011
  Monitor habitat conditions during spring emigration and maintain antenna arrays to develop estimates of the probability of smolt survival.

- Estimate the total smolt production for BY 2010 using the rotary trap at RM .3

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10.0 Appendices

Appendix 1

Monitoring sites on the Shasta River in Siskiyou County, California during the summer of 2008

Location		GPS Coordinates		Monitoring Method (Y=YES, N=NO)		
Site Name	**River Mile**	**Latitude**	**Longitude**	**Flow Transect**	**Dive Count**	**Temperature Logger**
SBS 1	32.9	041°35'41.76"N	122°26'42.15"W	N	Y	Y
SBS 2	33.3	041°35'39.56"N	122°26'37.90"W	N	Y	Y
SBS 3	33.4	041°35'36.10"N	122°26'34.69"W	N	Y	N
SBS 4	33.6	041°35'39.38"N	122°26'22.14"W	N	Y	Y
*BSC	-----	041°35'36.80"N	122°26'13.52"W	N	N	Y
SBS 5	33.7	041°35'35.37"N	122°26'15.36"W	N	N	Y
SBS 6	34.9	041°34'53.82"N	122°25'45.18"W	N	N	Y
**PC	-----	041°34’50.53”N	122°25'44.11”W	N	N	Y
HIG 1	35.0	041°34'47.00"N	122°25'41.00"W	Y	Y	Y
HIG 2	35.2	041°34'42.77"N	122°25'37.50"W	Y	Y	Y
HIG 3	36.0	041°34'9.27"N	122°25'31.63"W	Y	Y	Y
HIG 4	36.3	041°33'54.93"N	122°25'30.52"W	Y	Y	Y
HIG 5	36.8	041°33'46.70"N	122°25'8.47"W	Y	Y	Y
Clear Springs	37.0	041°33'43.41"N	122°24'56.09"W	N	N	Y
Fence Line	37.4	041°33'46.10"N	122°24'29.79"W	N	N	Y
† Kettle Springs	-----	041°32'58.14"N	122°25'38.58"W	Y	Y	Y
*BSC is located at the mouth of Big Springs Creek, a tributary to the Shasta River.						
** PC is located at the upstream boundary of Parks Creek on the Busk Ranch. Parks Creek is a tributary to the Shasta River.						
† Kettle Springs is the headwaters of Kettle Springs Creek, which empties into Parks Creek.						

Appendix 2
Fyke Net Specifications

3'X4' FYKE NET SPECIFICATIONS:

Frame: 36"H x 48"W. 2 frames made of 1/2" diameter welded conduit.
Netting: 3/16"square (3/8" stretch) #105 knotless nylon netting.
Hoops: Constructed of ¼" spring steel, 5 hoops. The first is 36" diameter with each succeeding hoop measuring approximately 1" smaller.
Lead: 3'H x 20'L attached to the center of the front frame. Netting is 3/16" square #105 knotless nylon stitched to a ¼" rope with SB-2 floats spaced every 4' on top and #50 pound lead line on bottom. A zipper is sewn to the lead for attachment to the center bar of the front frame of the trap.
Wings: Two wings, each 3'x15'. They will also have zippers for attachment to the sides of the front frame of the trap.
Winkers: Each net has two side winkers and one center winker, with 3" vertical slit openings.
Throats: Two throats, first attached to the first hoop tied to the third hoop with 1/8" diameter rope. The second, attached to the third hoop tied to the fifth hoop. Throats have a 4-5" opening.
Cod End: A 1/8" braided nylon rope is run through netting as a draw string to close the cod end.
Twine: Number 15 twine is used throughout the net.
Tie Spacing: Tie spacing on the hoops and frames is no further than 3" apart. Tie spacing on the leads is further than 8" apart.
Treatment: Nets and leads are treated with water-based black UV inhibitor net treatment.

2'X3' FYKE NET SPECIFICATIONS

Same as above except frame in 24"Hx36"W, 4 hoops, the first 24"diameter, 2'Hx15'L lead, and 2'Hx10'L wings.

Appendix 3. Rearing capture methods

Minnow Trap
Minnow traps were cylindrical in shape, 18" in length, 8" in circumference, and had an inverted cone on each end where fish could easily enter. Each trap was baited with cured salmon roe and either placed on the stream bottom or hung from a line attached to overhanging vegetation so that is set suspended in the water column. Each trap was fished for approximately 24 hours.

Seine Net

Seine nets were approximately 15'long by 4' high with a ¼" delta mesh pattern and had a float and lead line attached. Divers used these seine nets to capture coho salmon by encircling them with the seine and lifting the float and lead line simultaneously.

Fyke Net

Two different sized fyke nets were used during the study, one with an opening of 2'x 3' and one with an opening of 3'x 4'. A description of each fyke net is provided in Appendix 2. Fyke nets were always positioned on the stream bottom and the traps were often set completely submerged, with the lead line and one or two of the wings positioned to transect areas where snorkel divers had confirmed the presence of coho. These traps were fished for approximately 24 hours.

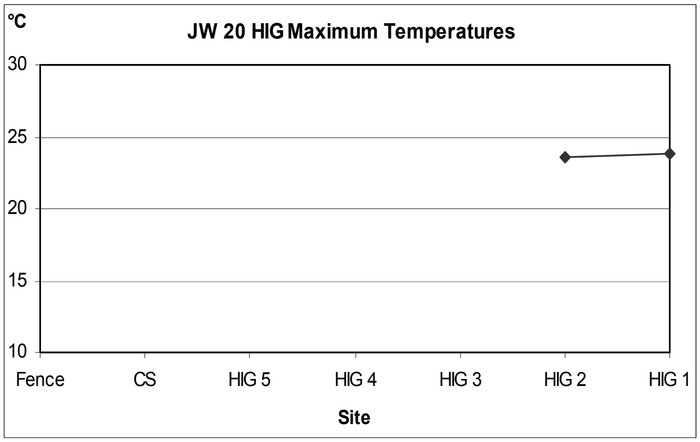
Hand Net

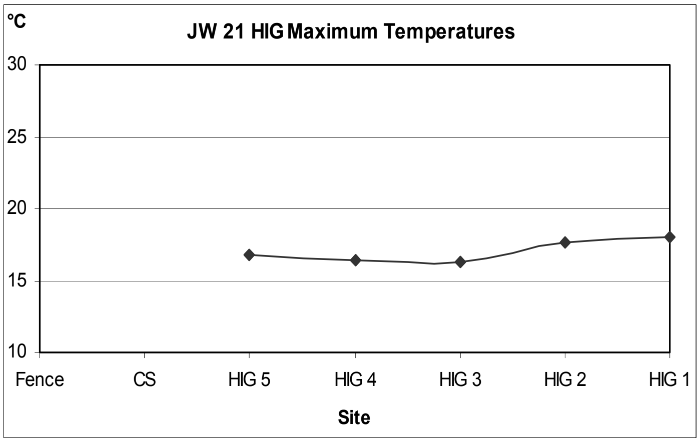
Hand nets were teardrop shaped with transparent netting attached to an opening that was 15"x 18" (Aquatic Ecosystems #TFN 101). Snorkel divers were successful in capturing juvenile coho salmon by using one of the following techniques. Once coho were found, divers would slowly approach and carefully lay the net on the stream bottom with an outstretched arm. Divers would then remain motionless until one or more juvenile coho salmon would position themselves over the net at which time the diver would quickly lift the net straight up out of the water, hopefully resulting in a capture. A second technique involved using one hand to position the net perpendicular to the stream bottom just downstream of holding fish. The other arm was then used to slowly encroach on the target fish from upstream causing it to turn and retreat into the awaiting net.

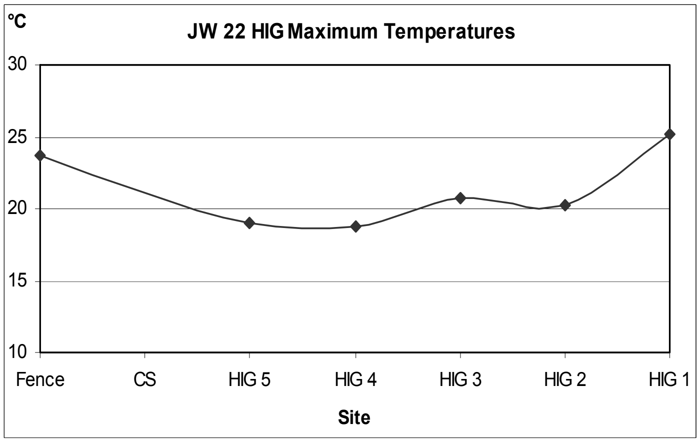
Appendix 4:
Table of Summer 2008 maximum temperatures per week per site

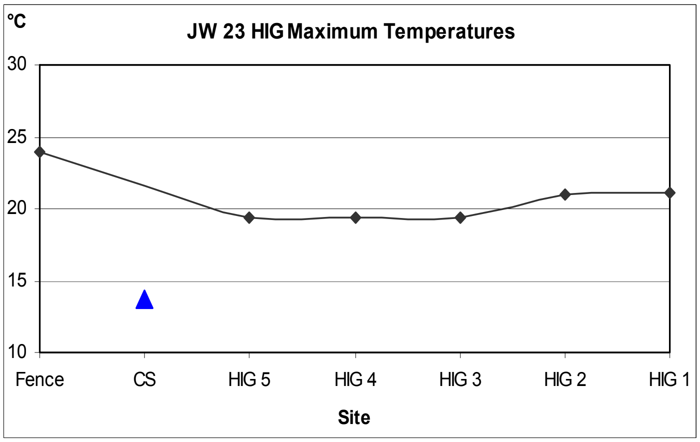
MAX TEMP/WEEK/SITE																
JW	KS	FENCE	CS	HIG 5	HIG 4	HIG 3	HIG 2	HIG 1	PC	SBS 6	SBS 5	BSO	BSC	SBS 4	SBS 2	SBS 1
13									13.738	13.906	14.385	12.63	17.034	16.82		
14									17.034	17.153	17.748	13.161	18.652	18.699		
15									19.888	19.984	21.008	13.858	20.507	20.889		
16									17.724	18.699	20.555	13.329	20.913	21.079		
17									21.342	20.698	20.627	14.074	22.298	21.581		21.461
18									20.484	20.579	21.008	15.652	22.92	22.896		22.13
19									20.007	20.007	21.079	15.461	21.891	21.939		21.413
20							23.545	23.809	24.968	24.895	25.866	16.606	25.137	24.726		24.605
21				16.8	16.463	16.272	17.677	17.986	18.176	18.224	18.723	14.481	20.198	20.079		19.08
22		23.761		19.05	18.723	20.793	20.198	25.186	23.04	22.753	23.328	15.175	22.848	22.92		22.657
23		23.954	13.642	19.37	19.341	19.389	21.032	21.079	23.064	22.202	22.082	15.151	21.413	21.628		20.126
24		25.355	13.666	20.5	19.912	19.936	21.915	22.274	24.702	23.424	23.304	15.963	23.424	23.641	23.761	21.032
25		25.283	13.69	19.37	19.627	20.246	21.939	24.919	24.291	19.199	23.136	16.701	23.208	23.617	23.472	20.627
26		26.891	13.69	19.53	20.817	21.795	25.404	25.501	24.363	17.772	24.219	17.605	23.689	24.026	24.219	20.793
27		27.407	13.666	21.16	21.032	21.987	22.513	23.4	18.794	21.461	23.569	18.414	23.088	23.28	23.593	20.579
28		28.345	13.666	21.16	21.724	24.412	21.7	23.04	28.742	22.92	24.05	17.153	23.521	23.545	24.026	20.913
29		26.744	13.69	20.02	20.984	21.485	19.46	27.456	27.53	22.537	23.617	16.606	21.772	21.939	22.657	19.674
30		24.992	13.69	18.24	20.746	20.96	20.65	20.841	26.304	22.345	23.328	16.272	21.103	21.27	21.987	19.032
31		25.72	13.618	19.05	20.317	20.579	20.484	20.603	26.231	20.722	21.939	16.582	21.008	21.246	21.772	19.008
32	14.553	25.574	13.594	18.866	20.555	20.936	20.126	20.436	25.453	20.913	22.13	16.939	20.96	21.581	21.915	19.032
33	14.581	28.419	13.594	20.555	21.724	21.819	21.509	21.294	24.871	23.04	23.088	17.938	21.103	21.246	22.393	18.889

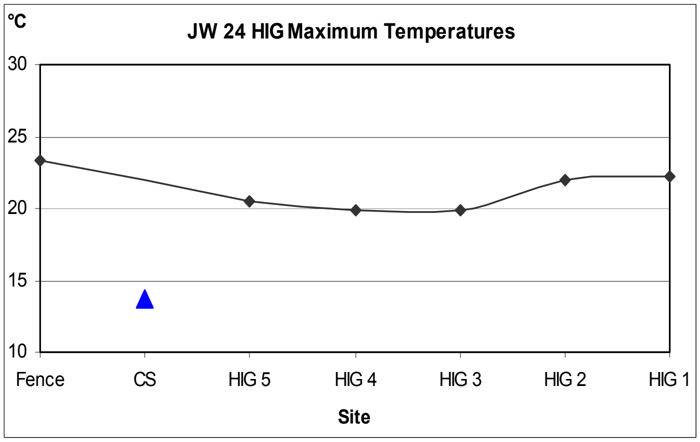
Appendix 5: Summer 2008 maximum temperatures per week

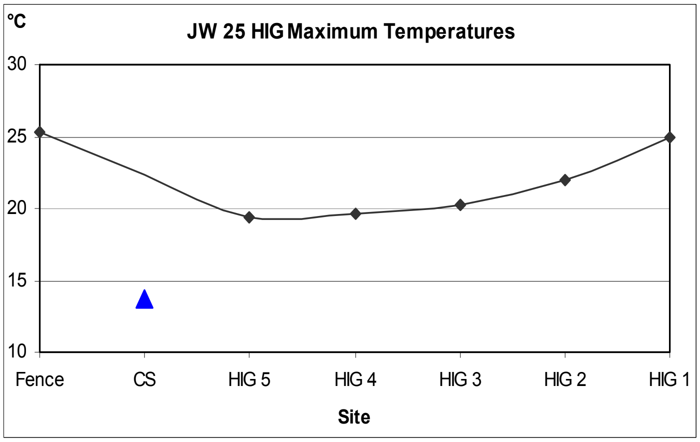


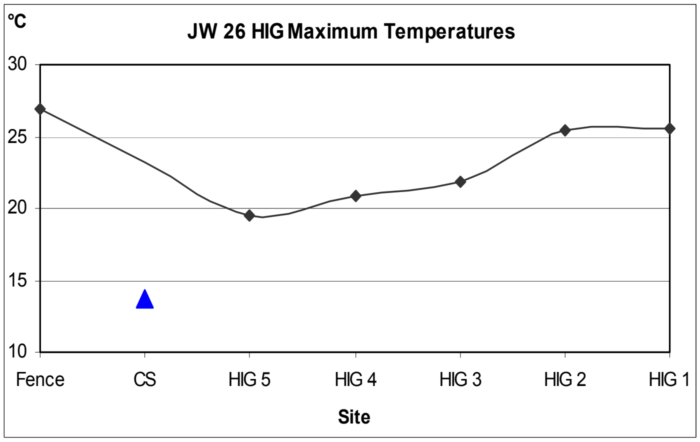


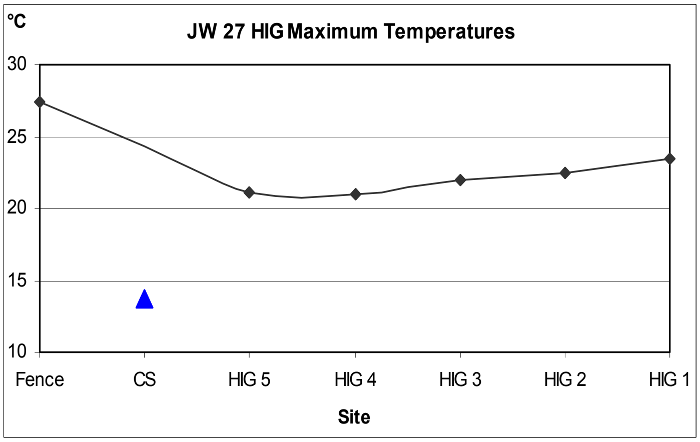




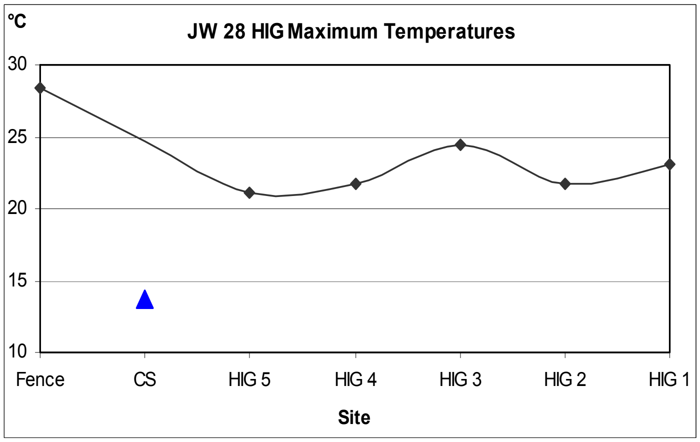


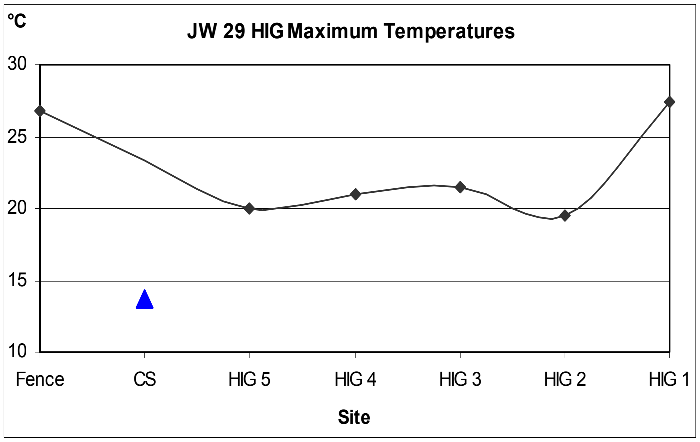


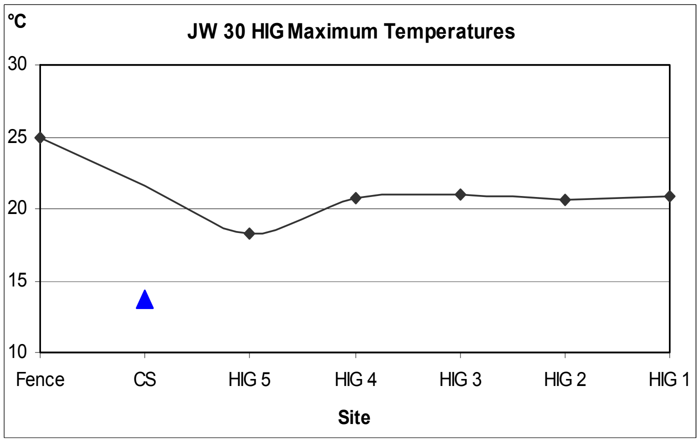


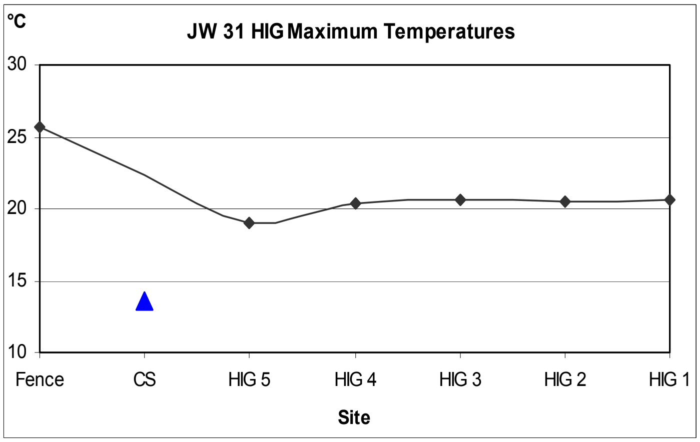


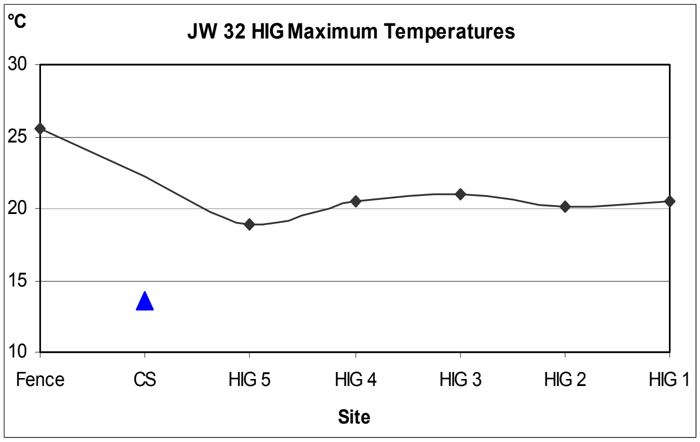
Appendix 5 (cont.): Summer 2008 maximum temperatures per week

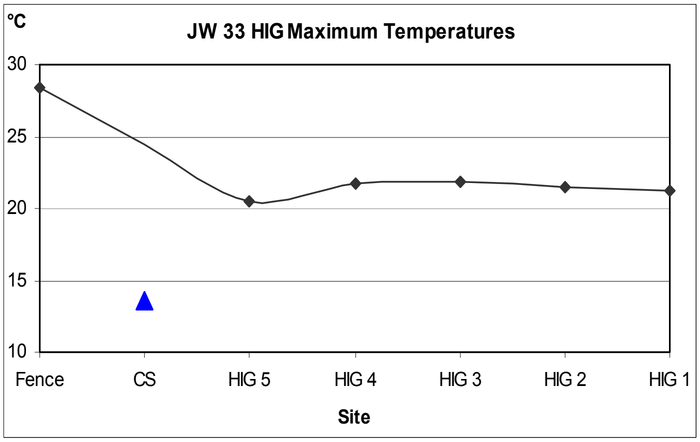




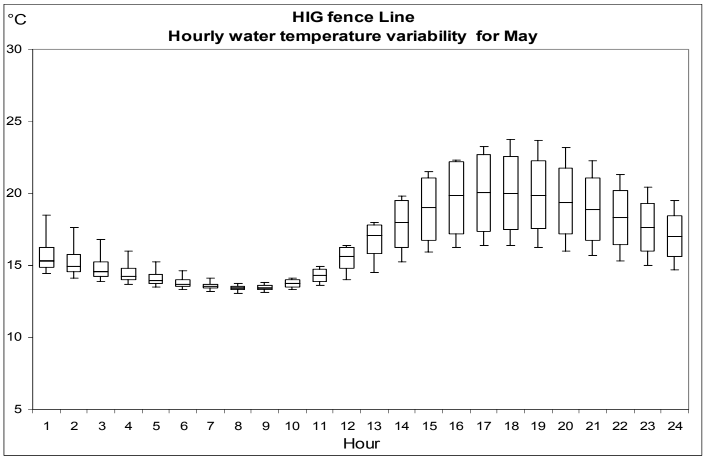


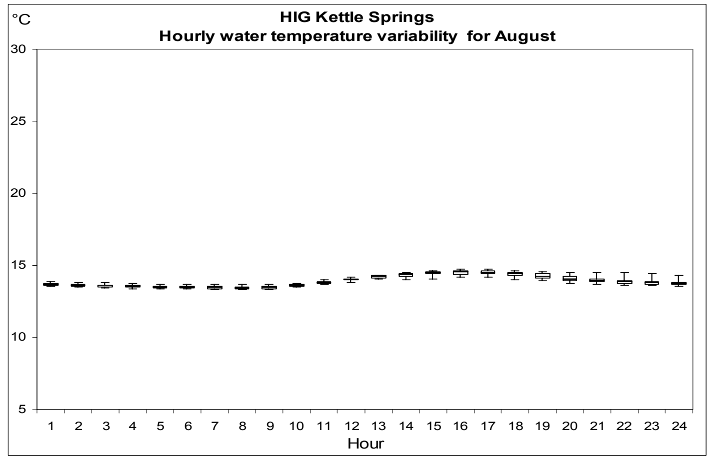


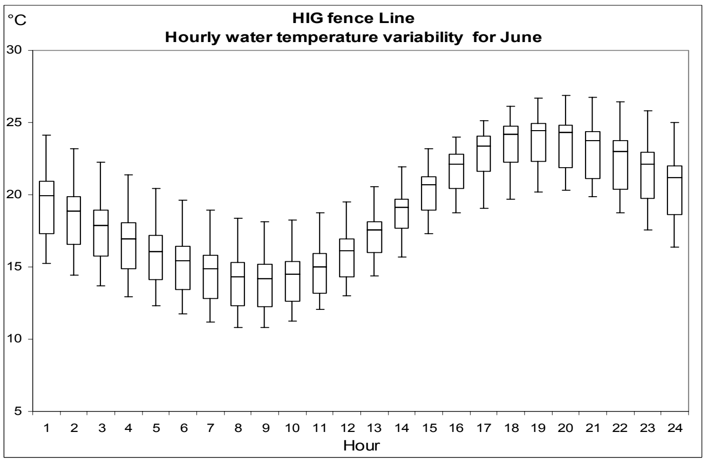


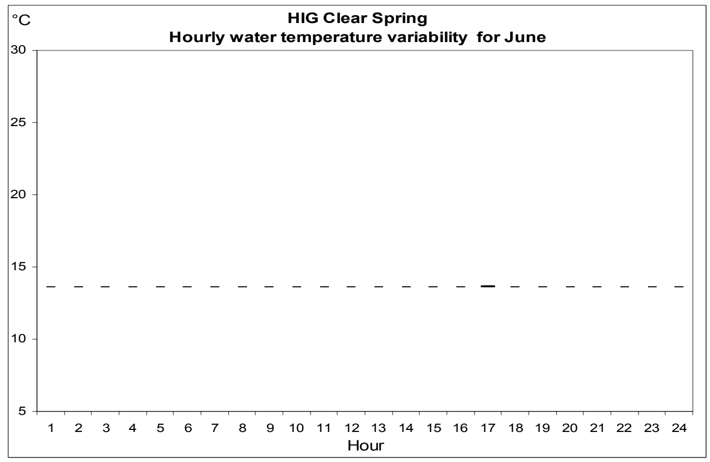


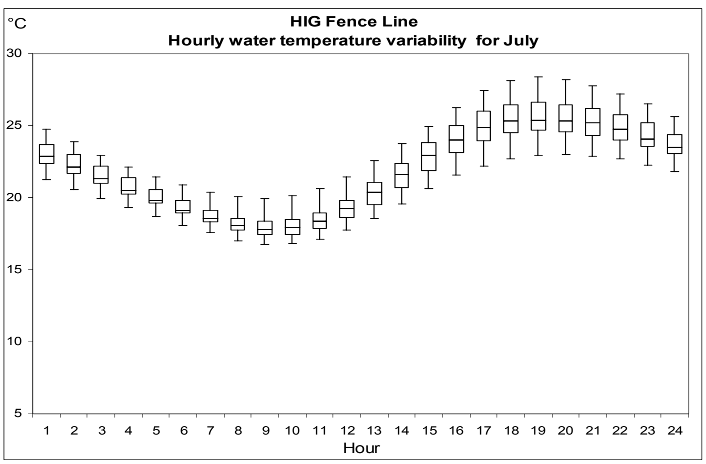
Appendix 6: Hourly temperature variability per month at temperature monitoring sites 2008.

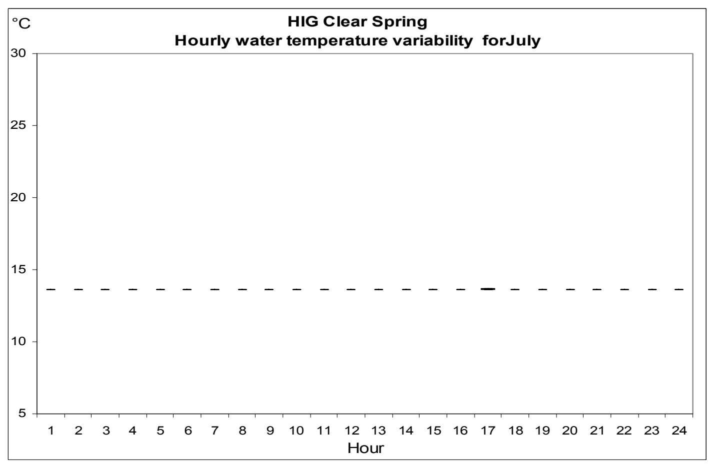


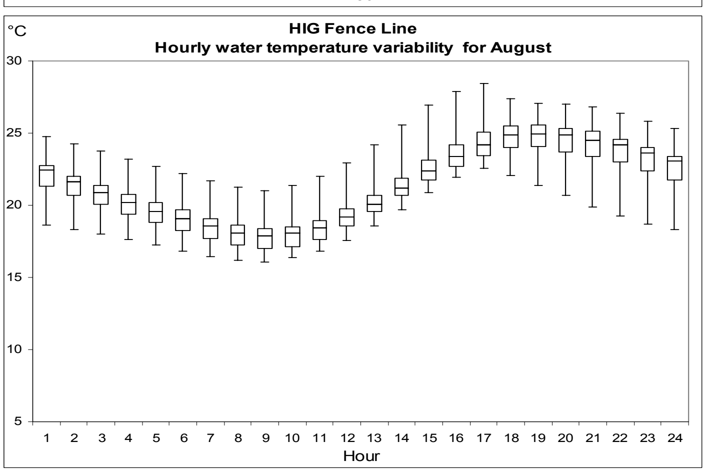


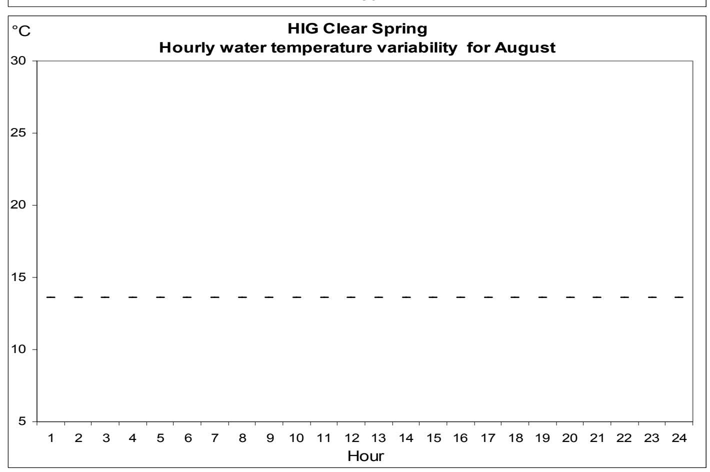




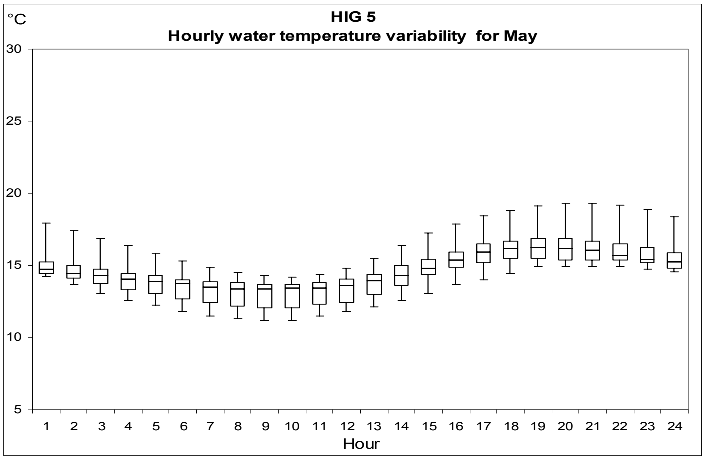


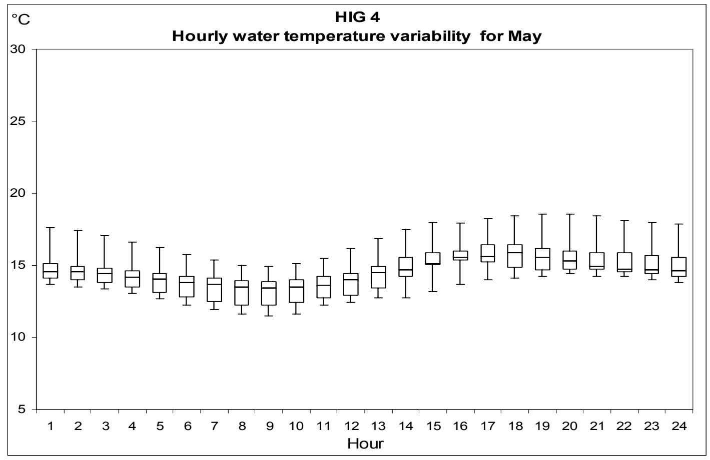


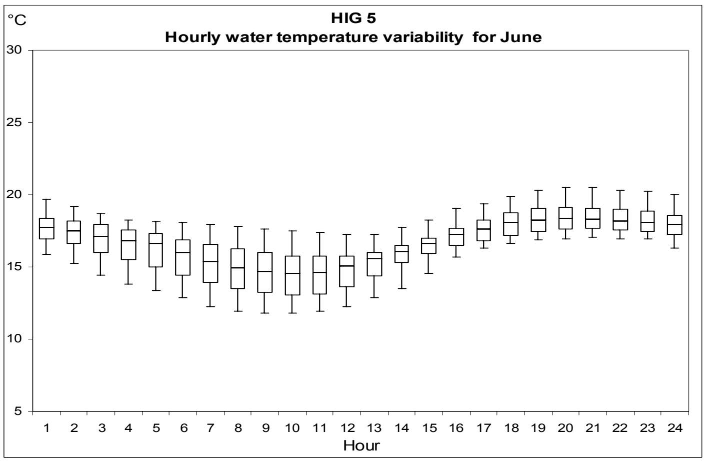


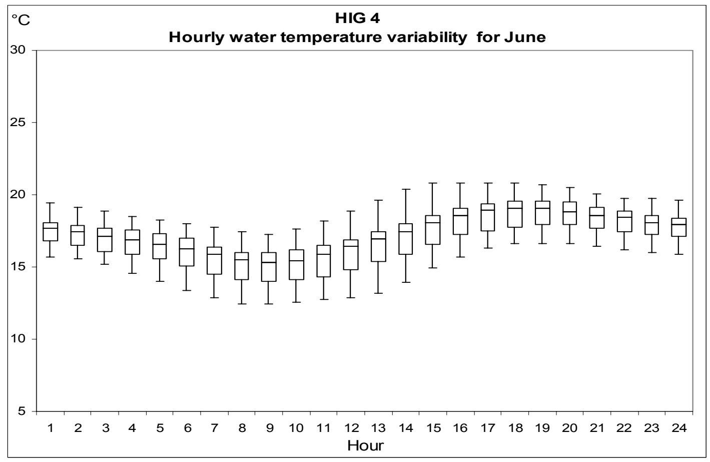


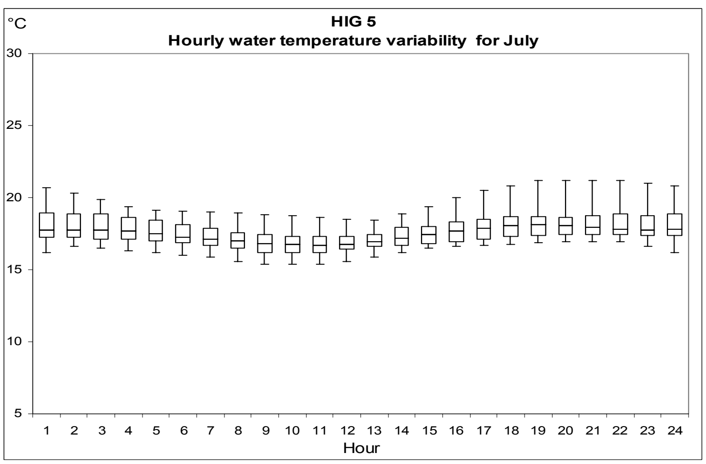
Appendix 6 (cont.): Hourly temperature variability per month at temperature monitoring sites 2008.

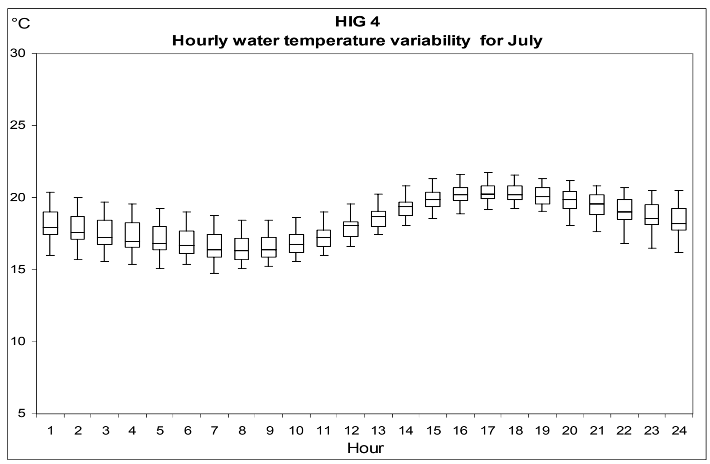


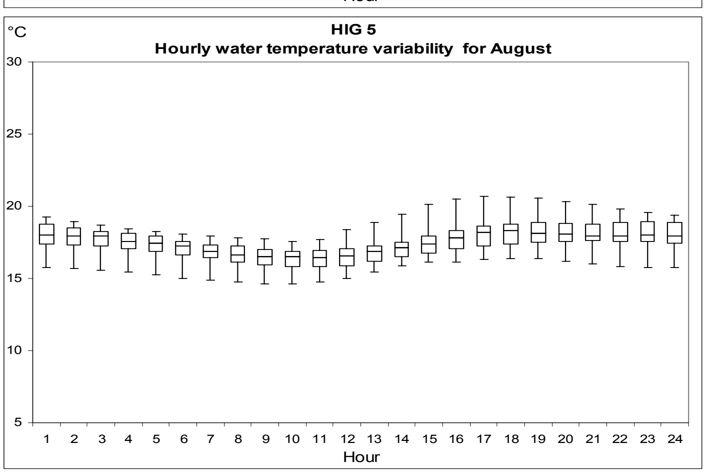


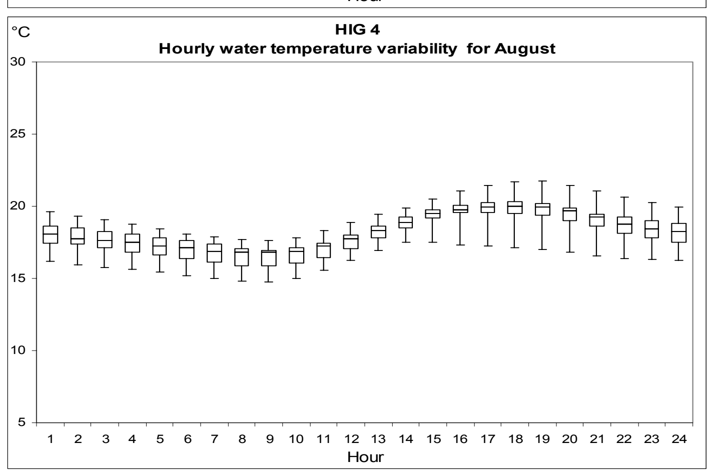




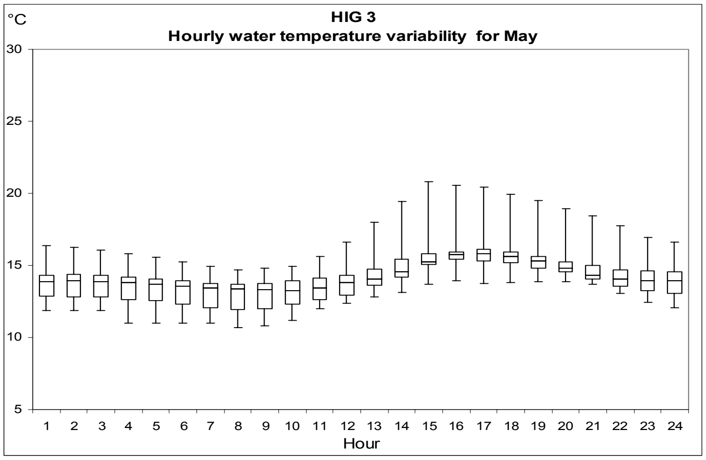


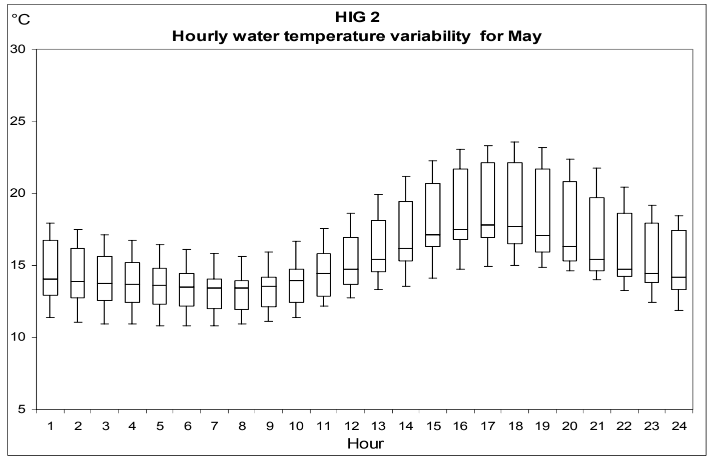


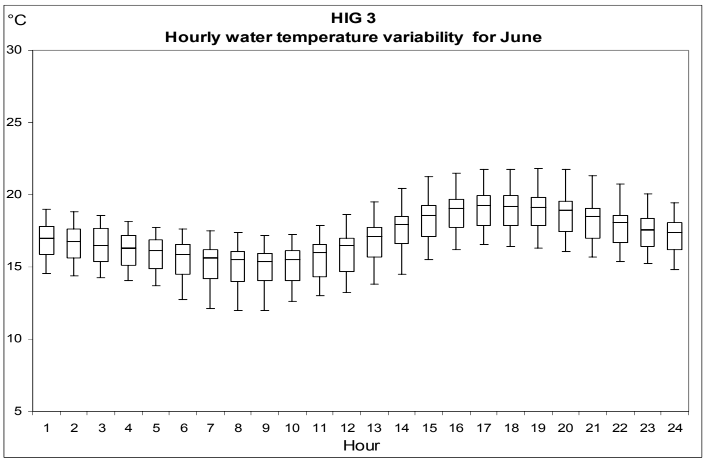


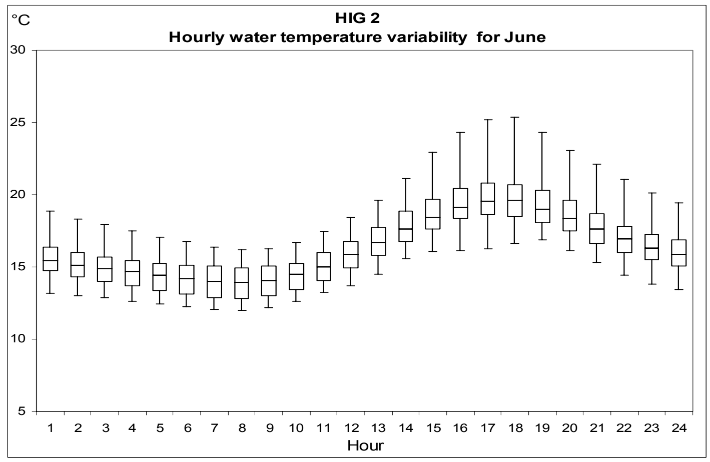


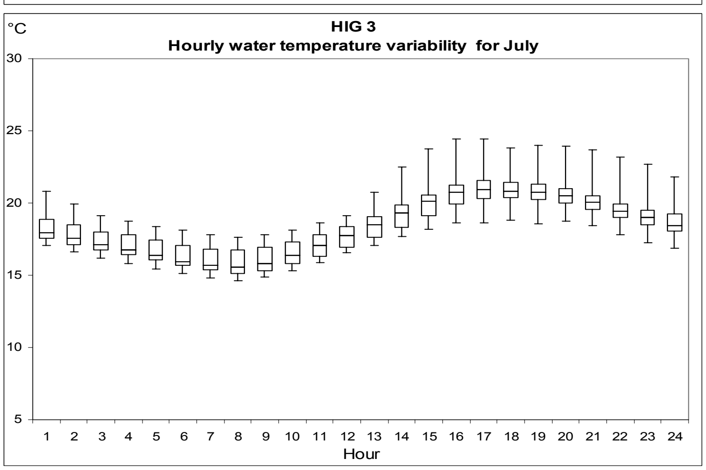
Appendix 6 (cont.): Hourly temperature variability per month at temperature monitoring sites 2008.

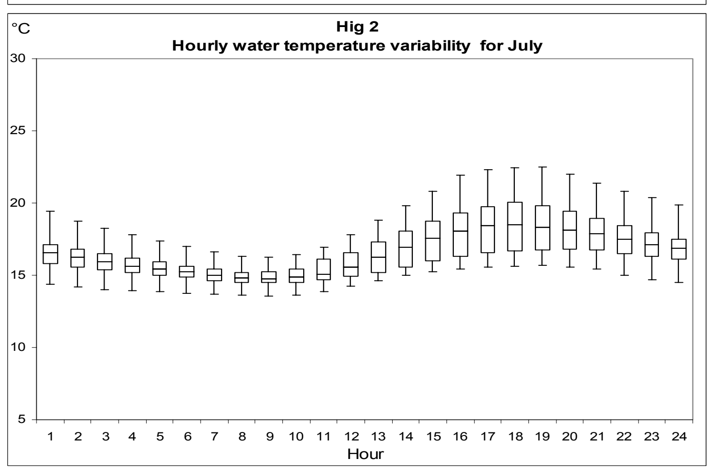


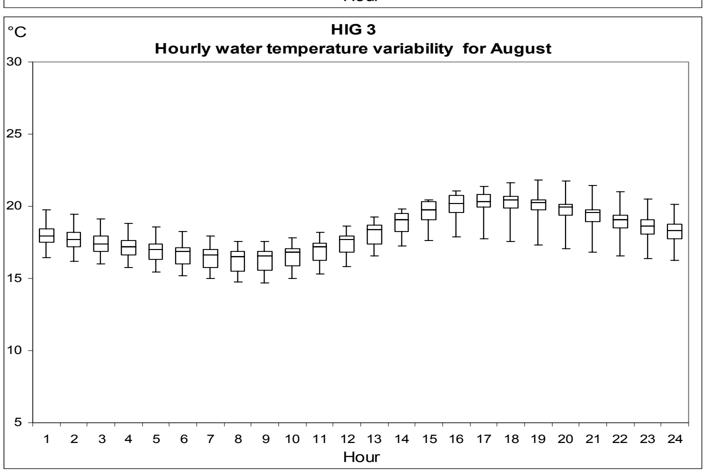


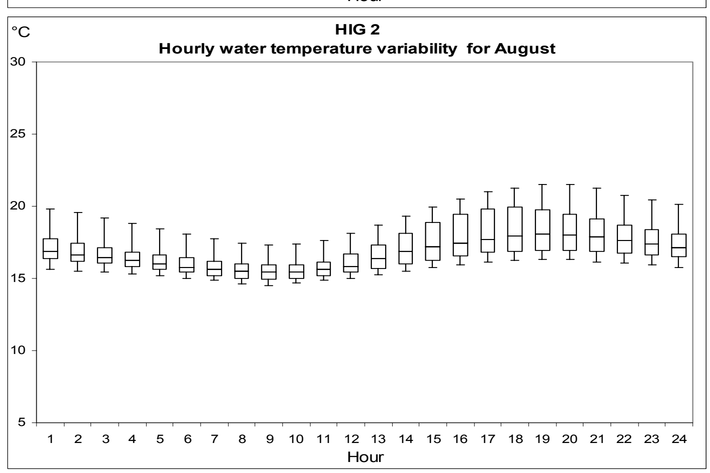




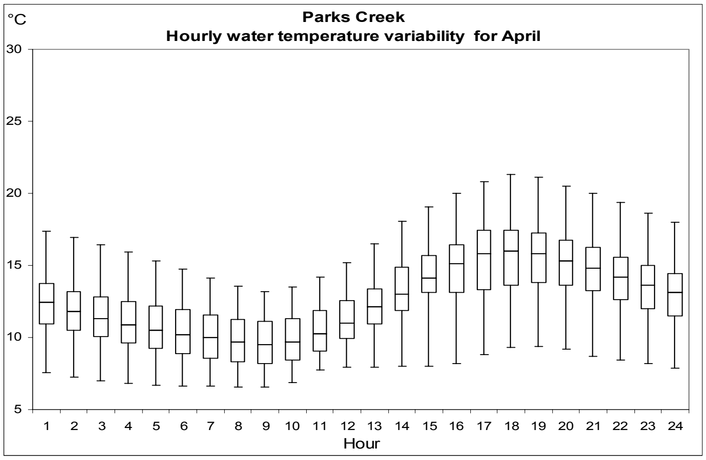


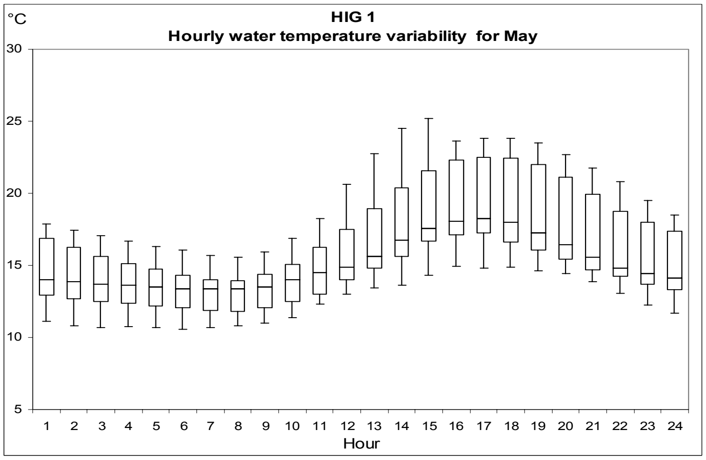


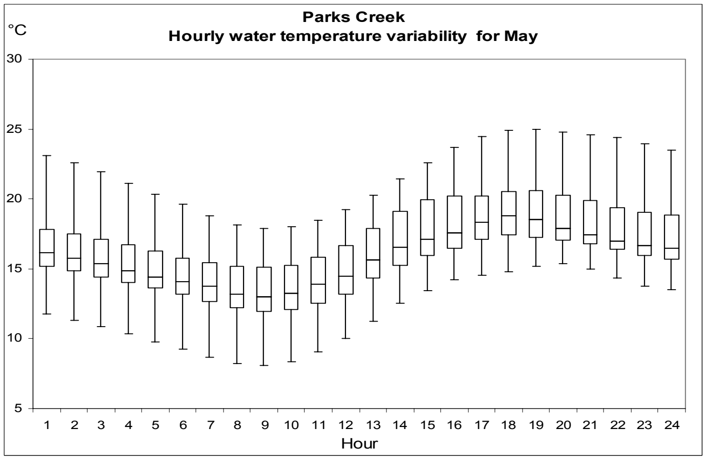


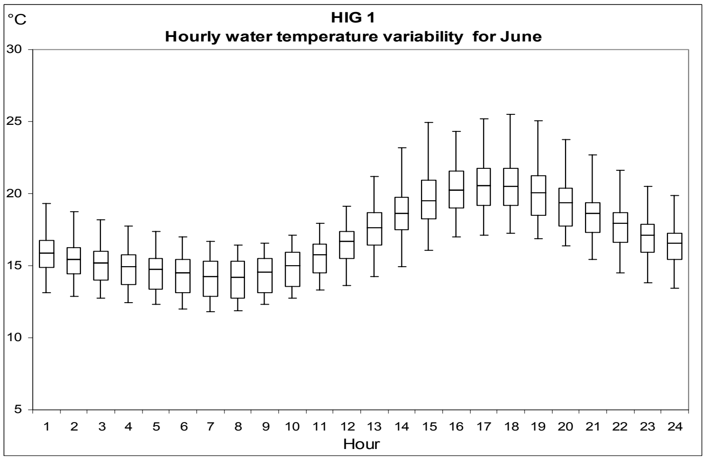


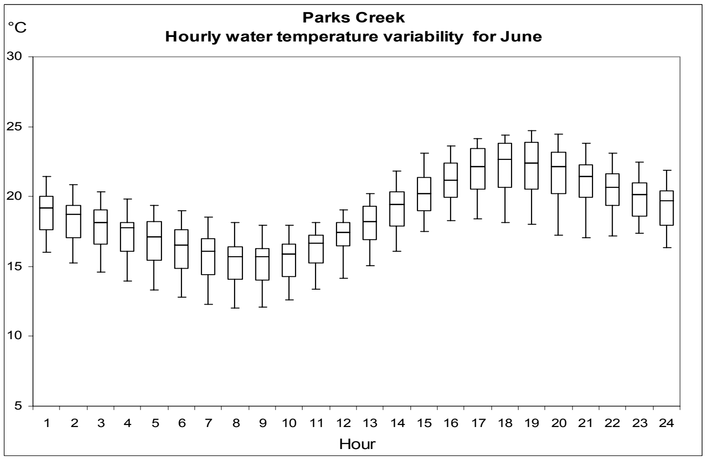
Appendix 6 (cont.): Hourly temperature variability per month at temperature monitoring sites 2008.

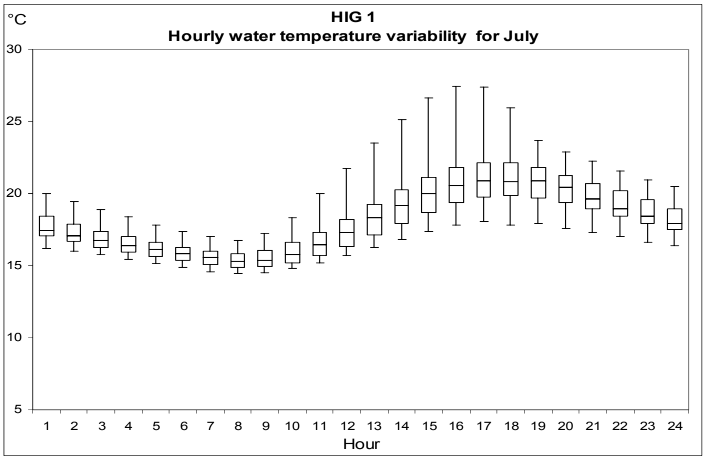


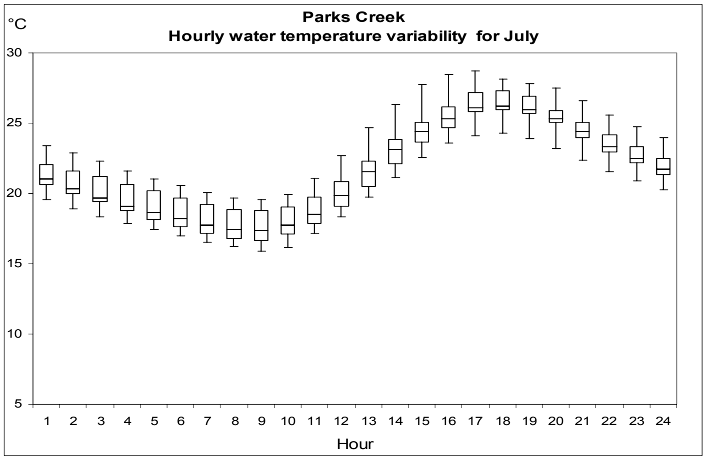




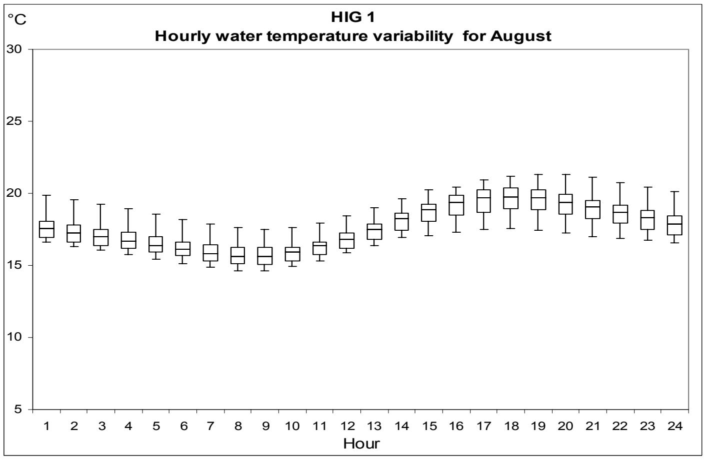


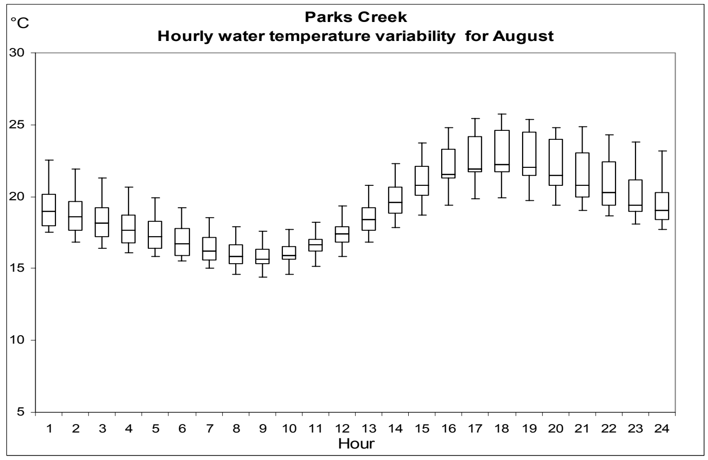


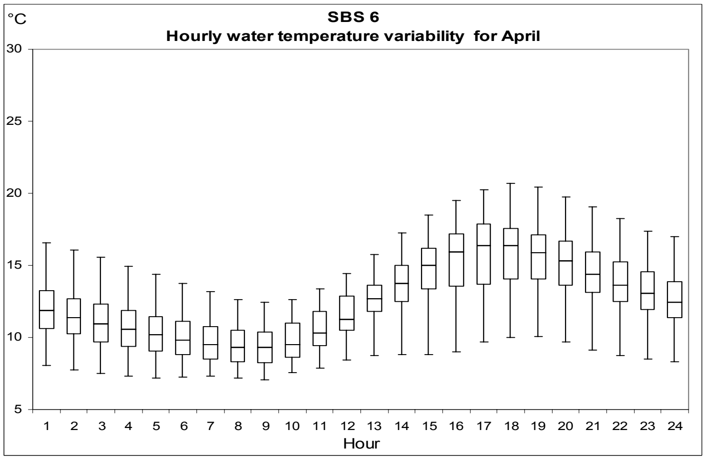


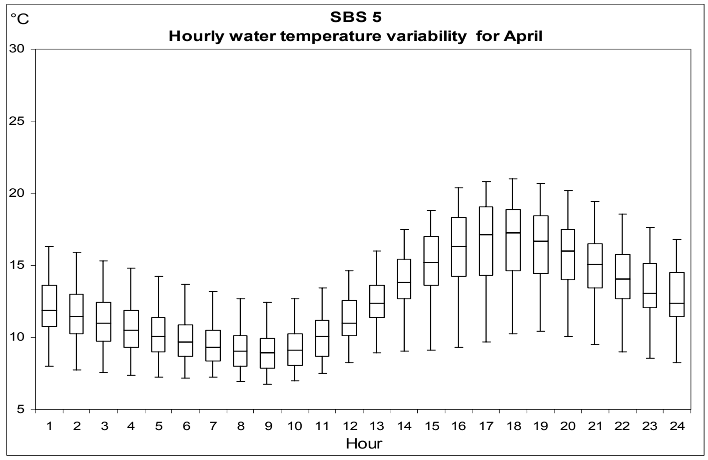


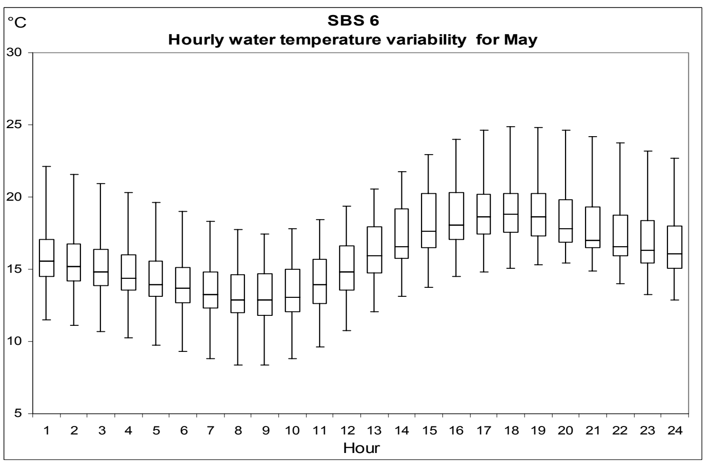
Appendix 6 (cont.): Hourly temperature variability per month at temperature monitoring sites 2008.

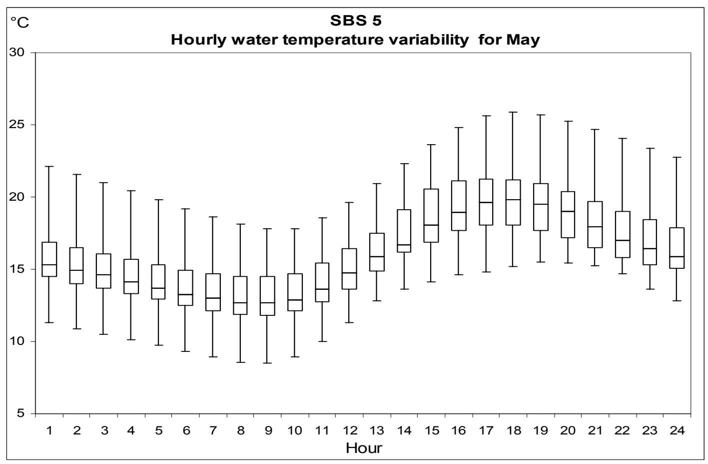


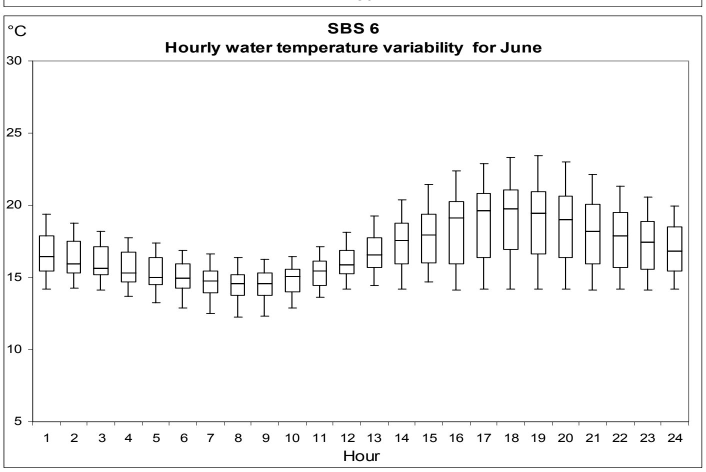


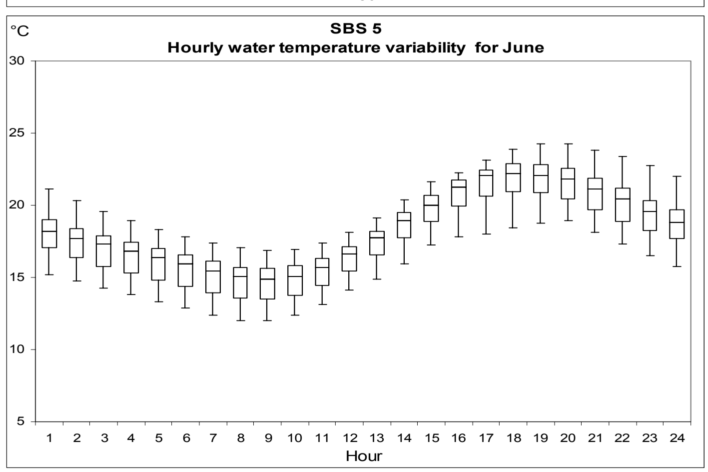




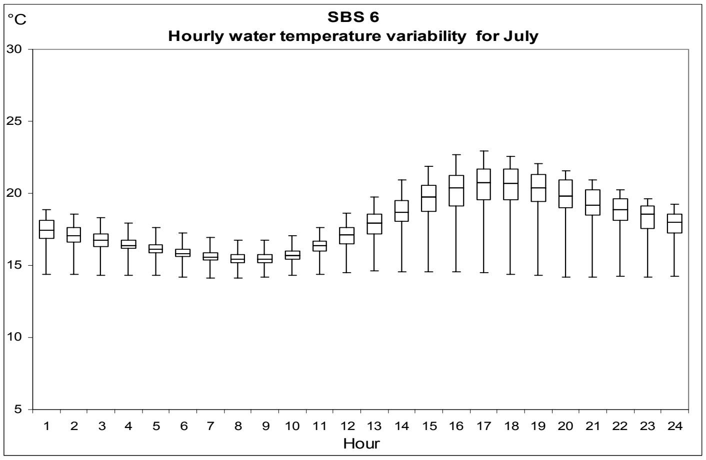


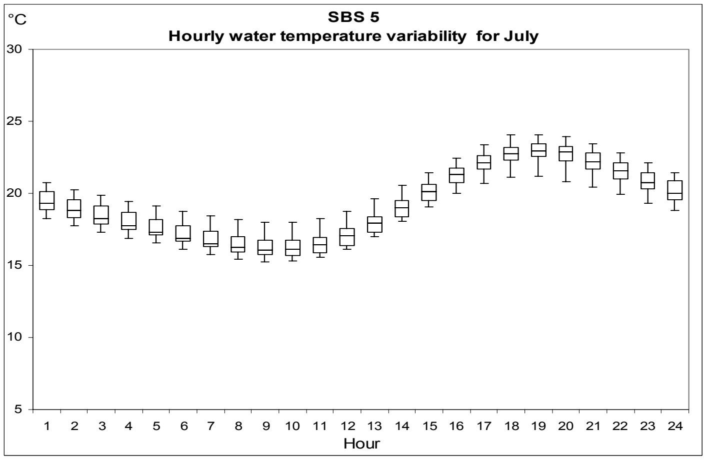


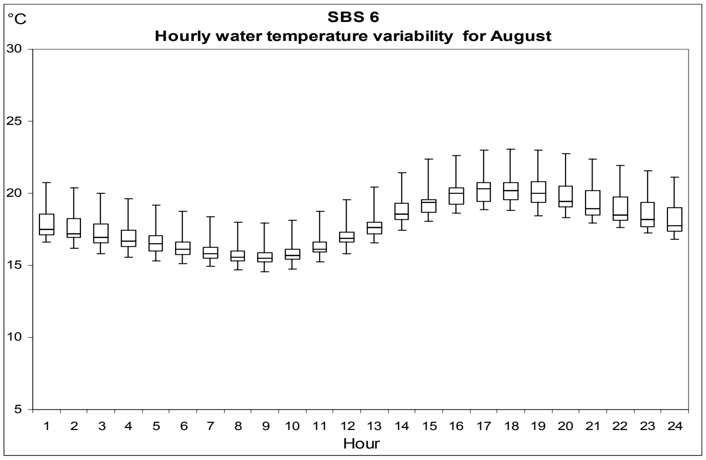


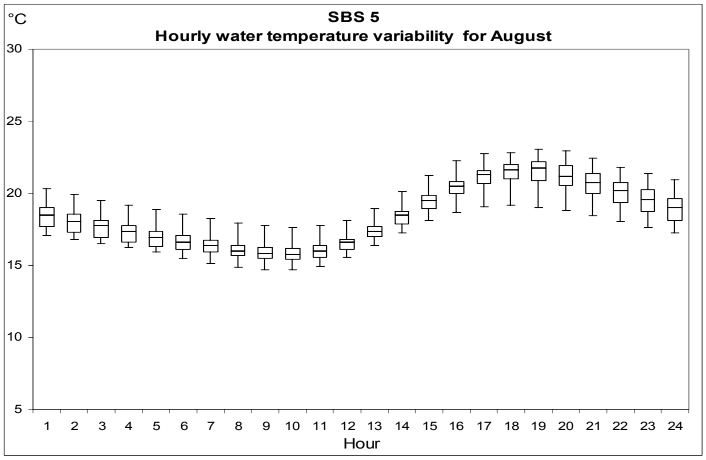


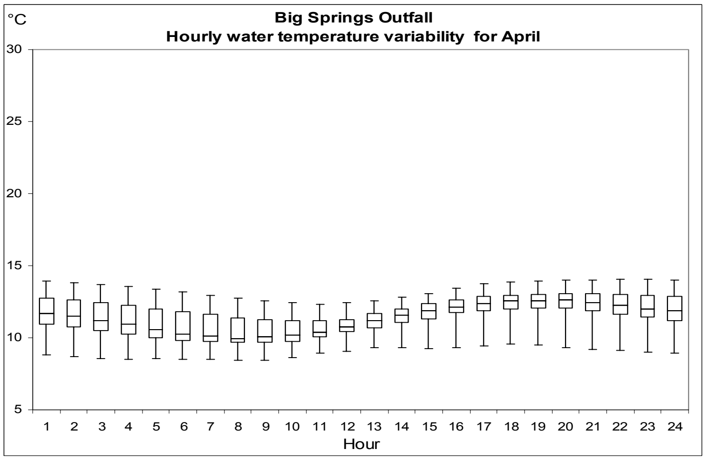
Appendix 6 (cont.): Hourly temperature variability per month at temperature monitoring sites 2008.

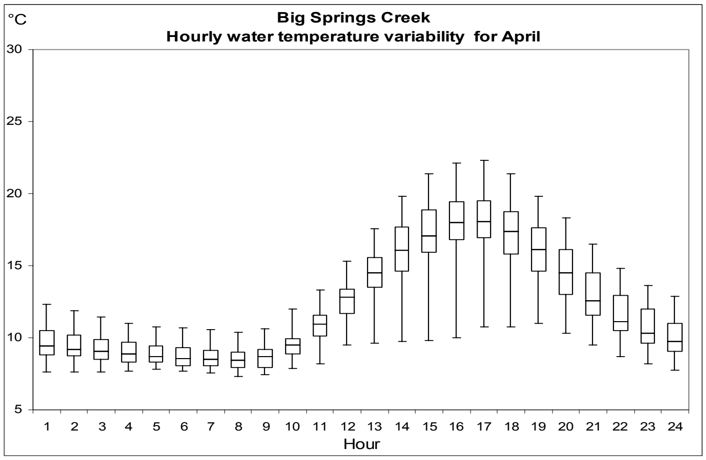


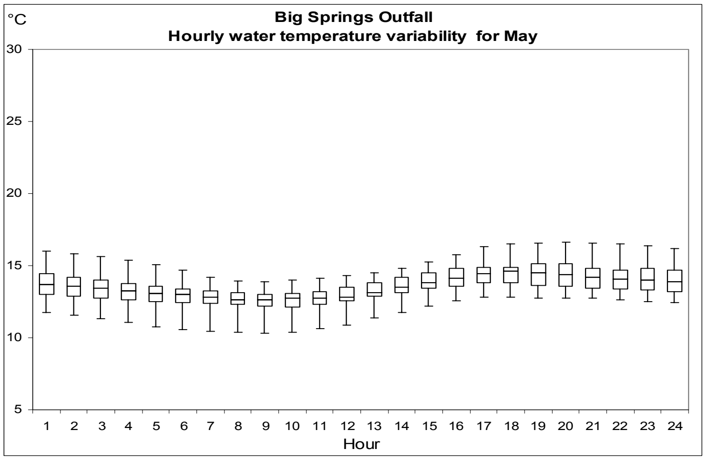


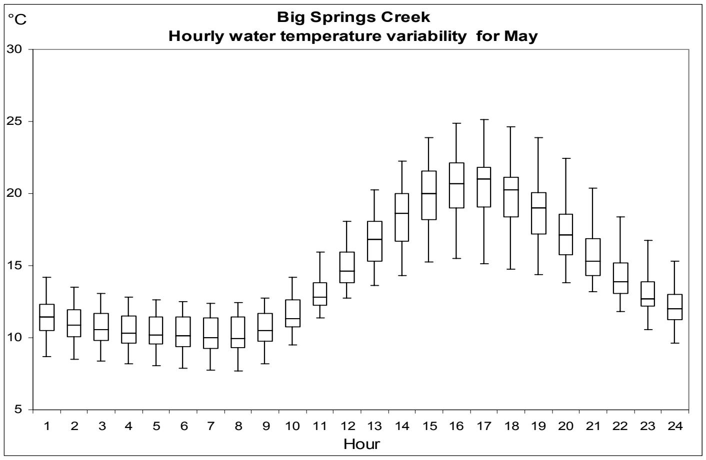




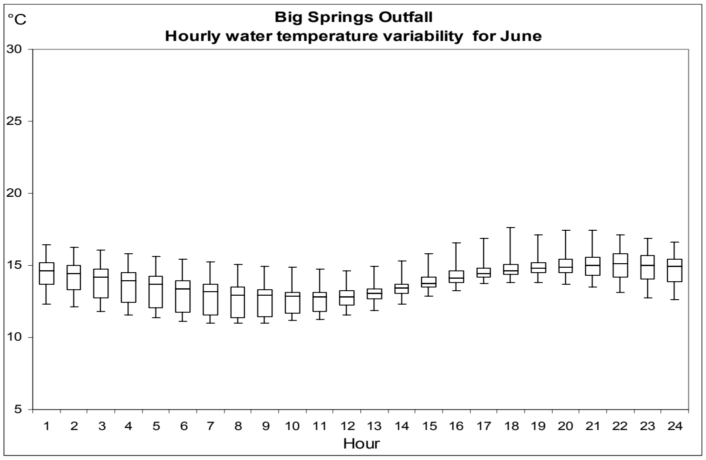


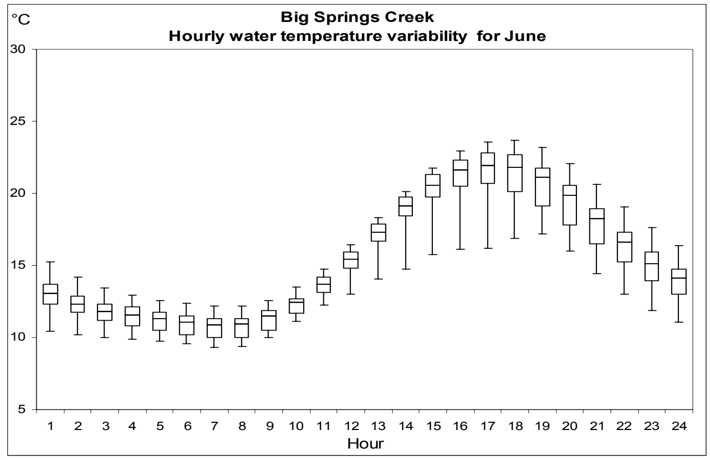


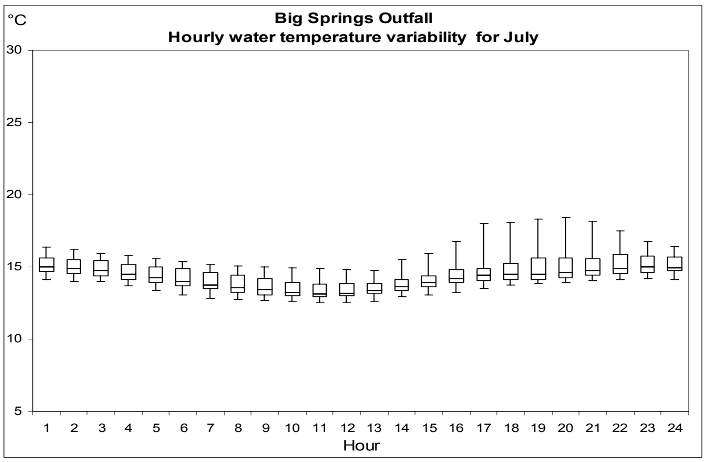


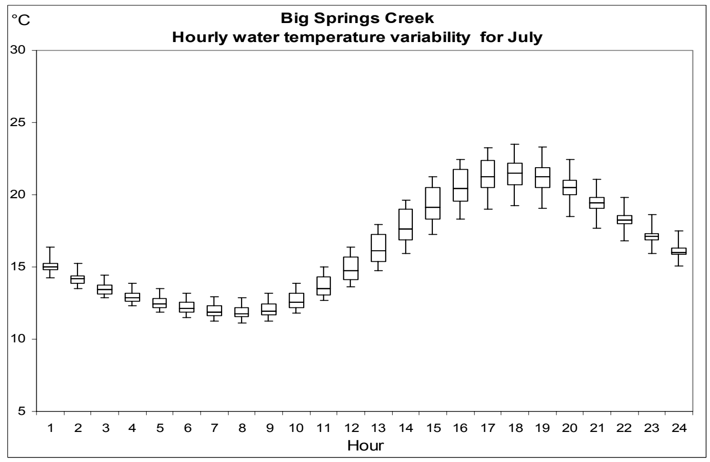


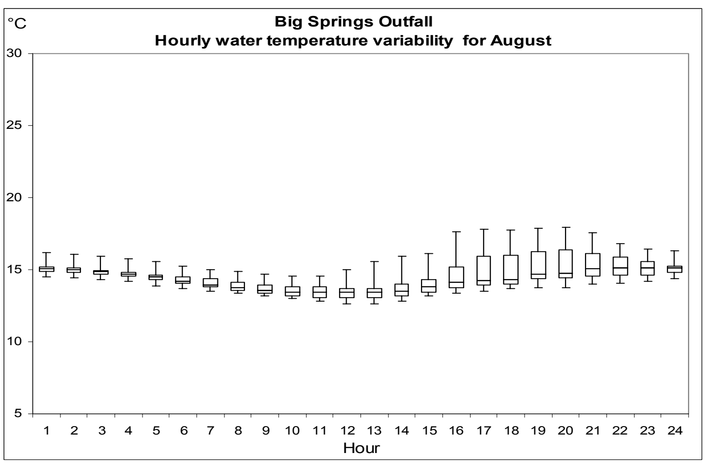
Appendix 6 (cont.): Hourly temperature variability per month at temperature monitoring sites 2008.

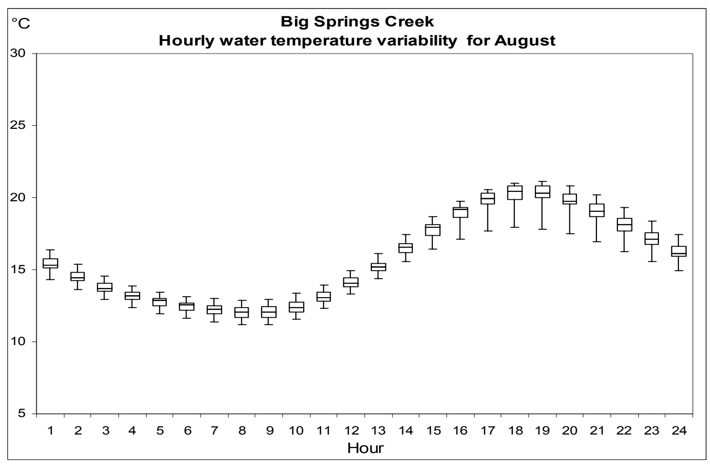


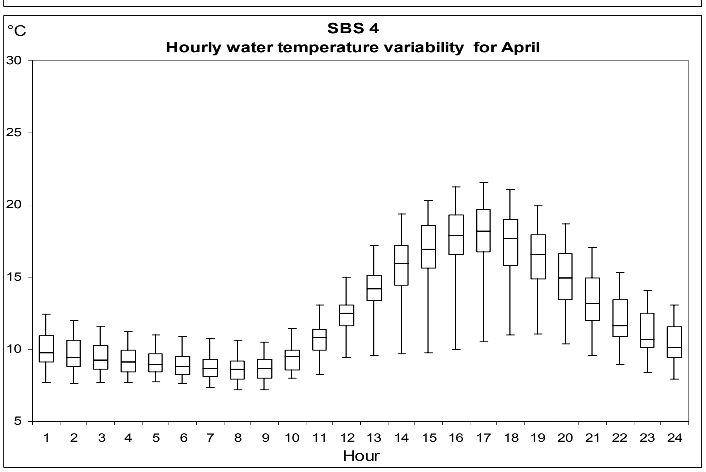




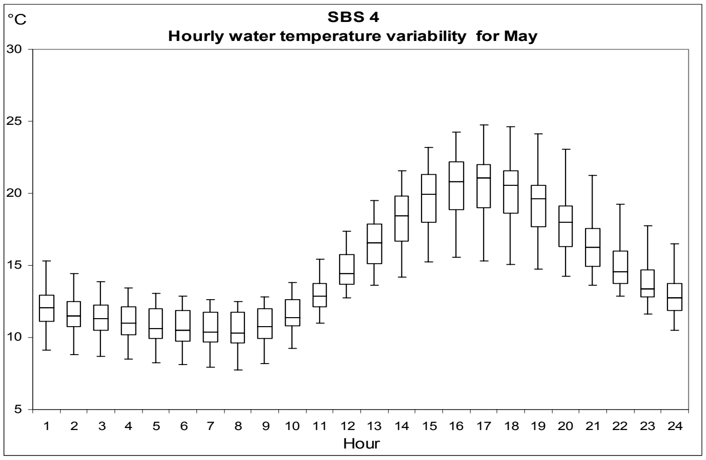


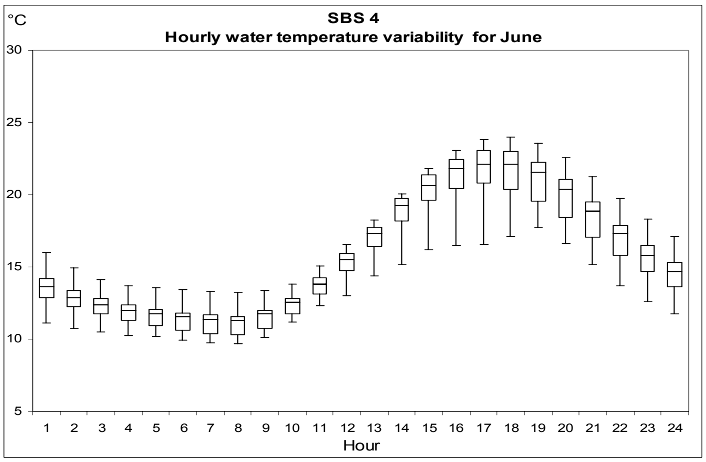


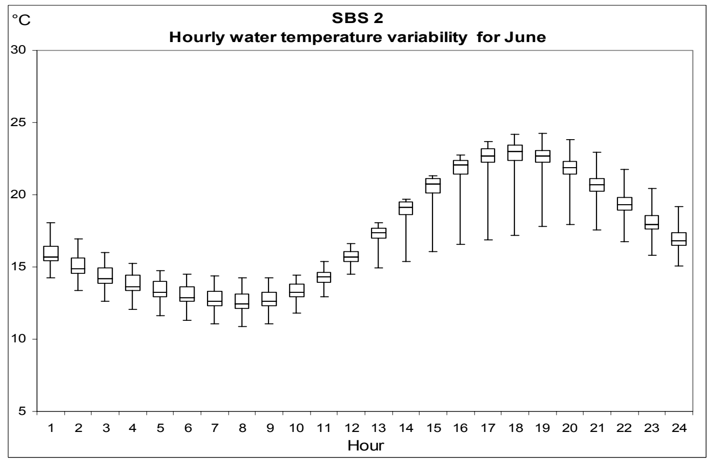


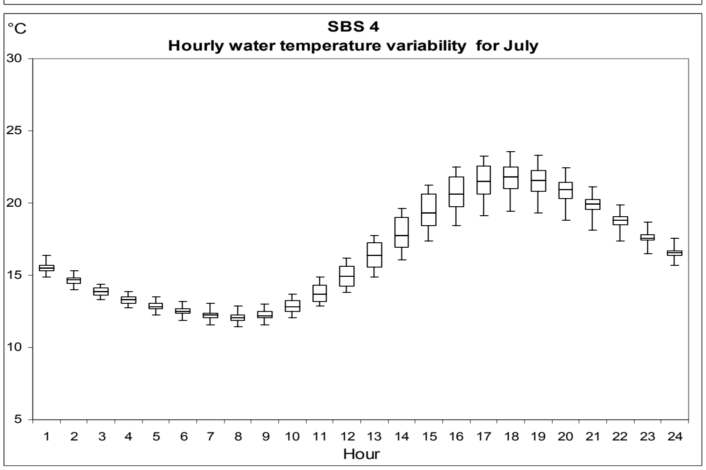


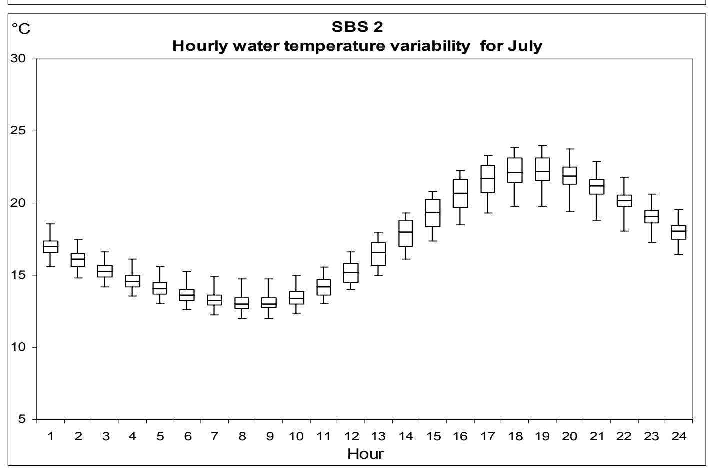
Appendix 6 (cont.): Hourly temperature variability per month at temperature monitoring sites 2008.

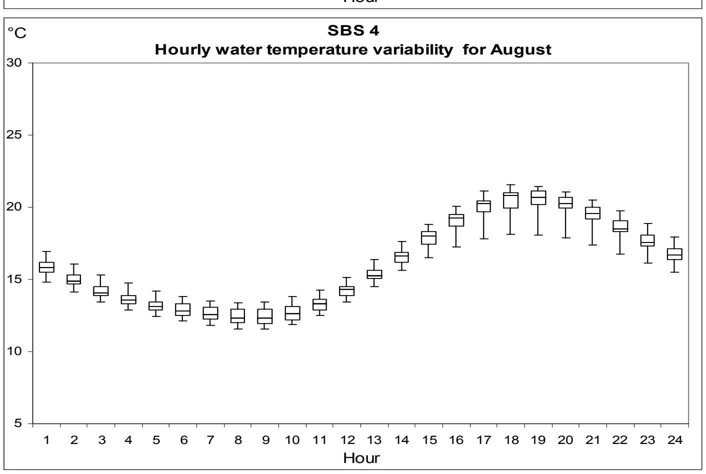


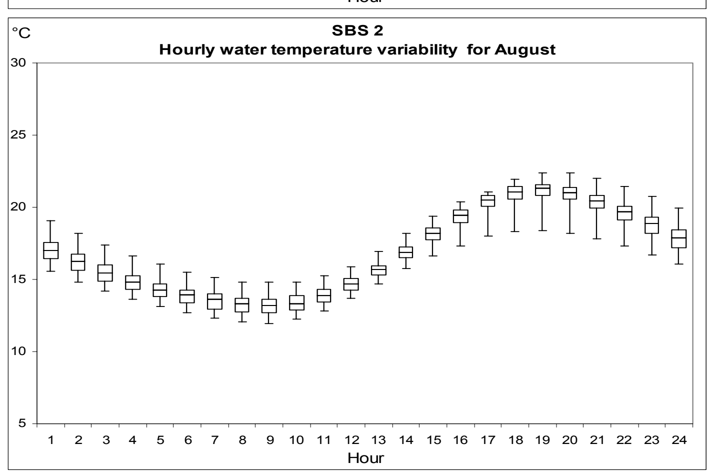




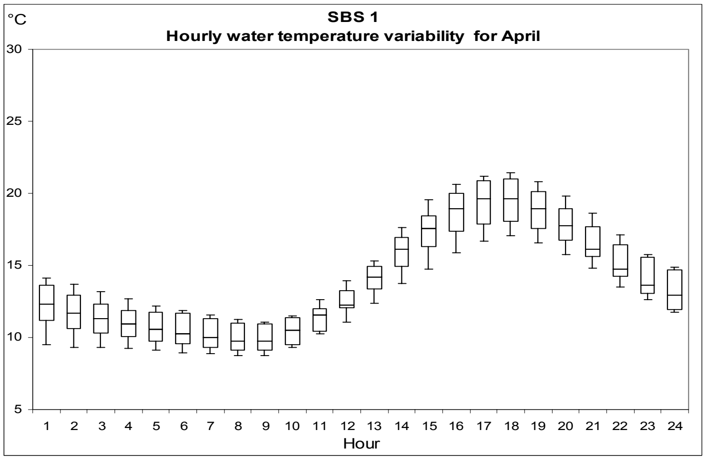


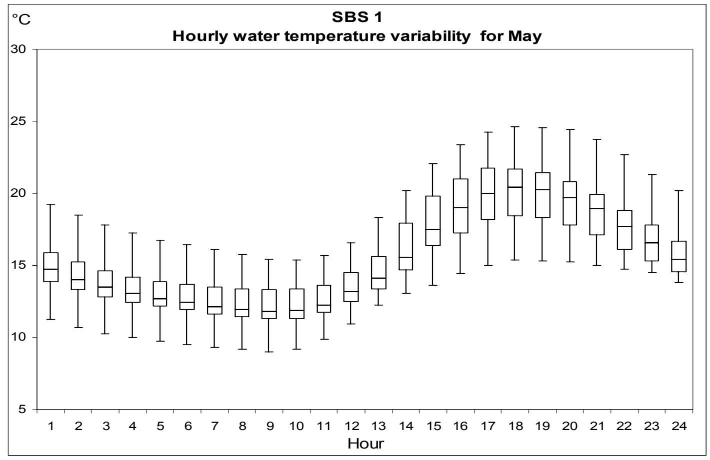


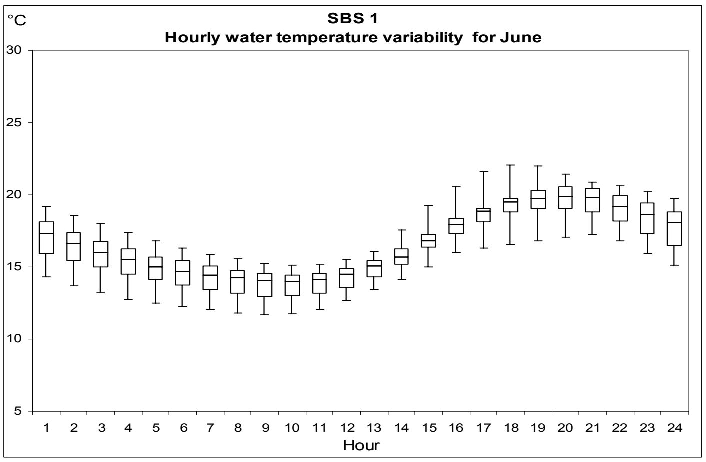


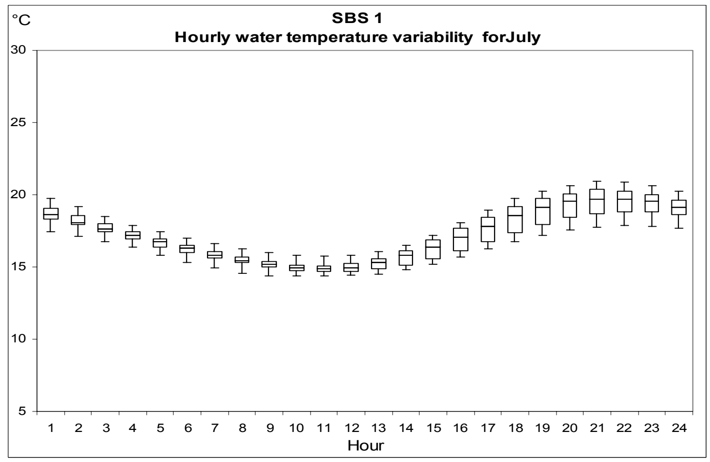


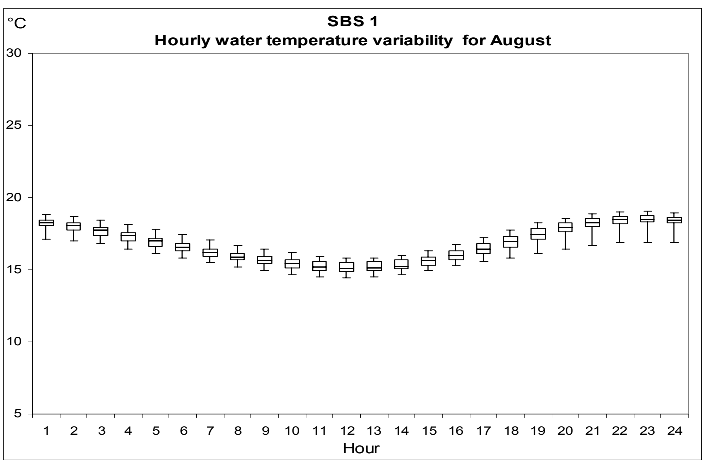
Appendix 6 (cont.): Hourly temperature variability per month at temperature monitoring sites 2008.











Appendix 7. Discharge(cfs) measured at five monitoring sites on the Shasta River at Hole in the Ground Ranch in 2008.

	HIG 5	HIG 4	HIG 3	HIG 2	HIG 1
13-May	----	----	----	----	5.83
27-May	----	2.76	1.42	4.63	3.73
11-Jun	8.65	2.89	1.66	7.82	5.55
24-Jun	----	----	----	5.70	6.44
8-Jul	5.77	1.16	1.30	5.64	6.36
21-Jul	9.69	0.99	1.86	6.53	5.87
6-Aug	6.00	2.99	1.75	----	----
12-Aug	6.12	3.02	----	----	-----
Mean	**7.25**	**2.30**	**1.30**	**6.06**	**5.63**
Min	**5.77**	**0.99**	**1.30**	**4.63**	**3.73**
Max	**9.69**	**3.02**	**1.86**	**7.82**	**6.44**
n	**5**	**6**	**5**	**5**	**6**

Appendix 8. Number of salmonids observed per visit from dive counts in the Shasta River at sites on Shasta Big Springs Ranch in 2008.

Site		10-Apr coho	10-Apr steelhead	10-Apr Chinook	17-Apr coho	17-Apr steelhead	17-Apr Chinook	23-Apr coho	23-Apr steelhead	23-Apr Chinook	1-May coho	1-May steelhead	1-May Chinook	8-May coho	8-May steelhead	8-May Chinook	15-May coho	15-May steelhead	15-May Chinook	21-May coho	21-May steelhead	21-May Chinook
SBS 1	Diver 1	22	0	4	55	2	1	71	0	0	26	3	1	18	2	0	0	2	0	1	7	0
	Diver 2	44	0	8	57	1	7	41	0	4	13	0	3	0	5	0	2	0	0	0	1	0
	Diver 3	--	--	--	--	--	--	51	0	2	3	0	2	--	--	--	0	3	0	--	--	--
	Diver 4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0	1	0	--	--	--
	Mean	**33**	**0**	**6**	**56**	**2**	**4**	**54**	**0**	**2**	**14**	**1**	**2**	**9**	**4**	**0**	**1**	**2**	**0**	**1**	**4**	**0**
	stdev	**16**	**0**	**3**	**1**	**1**	**4**	**15**	**0**	**2**	**12**	**2**	**1**	**13**	**2**	**0**	**1**	**1**	**0**	**1**	**4**	**0**
SBS 2	Diver 1	30	1	28	66	4	6	73	0	6	49	9	3	14	0	0	10	1	0	--	--	--
	Diver 2	30	0	41	12	2	0	38	0	18	45	0	2	--	--	--	11	8	2	--	--	--
	Diver 3	--	--	--	--	--	--	34	0	0	68	0	0	--	--	--	10	3	0	--	--	--
	Diver 4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	9	0	0	--	--	--
	Mean	**30**	**1**	**35**	**39**	**3**	**3**	**48**	**0**	**8**	**54**	**3**	**2**	**14**	**0**	**0**	**10**	**3**	**1**	**--**	**--**	**--**
	stdev	**0**	**1**	**9**	**38**	**1**	**4**	**21**	**0**	**9**	**12**	**5**	**2**	**10**	**0**	**0**	**1**	**4**	**1**	**--**	**--**	**--**
SBS 3	Diver 1	2	0	6	4	0	2	0	0	0	1	13	1	1	9	0	0	23	0	--	--	--
	Diver 2	--	--	--	--	--	--	0	0	0	--	--	--	--	--	--	0	3	0	--	--	--
	Diver 3	--	--	--	--	--	--	13	0	2	--	--	--	--	--	--	0	15	3	--	--	--
	Diver 4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0	4	3	--	--	--
	Mean	**2**	**0**	**6**	**4**	**0**	**2**	**4**	**0**	**1**	**1**	**13**	**1**	**1**	**9**	**0**	**0**	**11**	**2**	**--**	**--**	**--**
	stdev	**--**	**--**	**--**	**--**	**--**	**--**	**8**	**0**	**1**	**--**	**--**	**--**	**--**	**--**	**--**	**0**	**10**	**2**	**--**	**--**	**--**
SBS 4	Diver 1	9	0	76	44	2	18	52	0	21	21	29	0	0	39	0	0	17	0	0	7	0
	Diver 2	--	--	--	--	--	--	6	0	21	15	0	2	2	14	1	1	14	2	1	3	0
	Diver 3	--	--	--	--	--	--	0	1	0	--	--	--	--	--	--	2	14	2	--	--	--
	Diver 4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2	0	9	--	--	--
	Mean	**9**	**0**	**76**	**44**	**2**	**18**	**19**	**0**	**14**	**18**	**15**	**1**	**1**	**27**	**1**	**1**	**11**	**3**	**1**	**5**	**0**
	stdev	**--**	**--**	**--**	**--**	**--**	**--**	**28**	**1**	**12**	**4**	**21**	**1**	**1**	**18**	**1**	**1**	**8**	**4**	**1**	**3**	**0**

Site		22-May coho	22-May steelhead	22-May Chinook	29-May coho	29-May steelhead	29-May Chinook	5-Jun coho	5-Jun steelhead	5-Jun Chinook	12-Jun coho	12-Jun steelhead	12-Jun Chinook	19-Jun coho	19-Jun steelhead	19-Jun Chinook	3-Jul coho	3-Jul steelhead	3-Jul Chinook	17-Jul coho	17-Jul steelhead	17-Jul Chinook
SBS 1	Diver 1	--	--	--	0	1	0	0	3	0	0	0	0	0	0	0	0	2	0	0	6	0
	Diver 2	--	--	--	--	--	--	0	2	0	--	--	--	0	1	0	0	3	0	0	2	0
	Diver 3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0	8	0	0	0	0
	Diver 4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Mean	**--**	**--**	**--**	**0**	**1**	**0**	**0**	**3**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**4**	**0**	**0**	**3**	**0**
	stdev	**--**	**--**	**--**	**--**	**--**	**--**	**0**	**1**	**0**	**--**	**--**	**--**	**0**	**1**	**0**	**0**	**3**	**0**	**0**	**3**	**0**
SBS 2	Diver 1	7	13	2	2	12	0	9	13	0	6	9	0	6	4	0	1	8	0	2	17	0
	Diver 2	0	25	0	--	--	--	1	6	0	--	--	--	0	2	0	0	5	0	1	28	0
	Diver 3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1	9	0	0	24	0
	Diver 4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Mean	**4**	**19**	**1**	**2**	**12**	**0**	**5**	**10**	**0**	**6**	**9**	**0**	**3**	**3**	**0**	**1**	**7**	**0**	**1**	**23**	**0**
	stdev	**5**	**8**	**1**	**--**	**--**	**--**	**6**	**5**	**0**	**--**	**--**	**--**	**4**	**1**	**0**	**1**	**2**	**0**	**1**	**6**	**0**
SBS 3	Diver 1	0	6	0	0	19	0	0	12	0	0	17	0	0	15	0	0	15	0	0	18	0
	Diver 2	--	--	--	0	8	0	0	14	0	--	--	--	--	--	--	0	16	0	0	18	0
	Diver 3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0	7	0
	Diver 4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Mean	**0**	**6**	**0**	**0**	**14**	**0**	**0**	**13**	**0**	**0**	**17**	**0**	**0**	**15**	**0**	**0**	**16**	**0**	**0**	**14**	**0**
	stdev	**--**	**--**	**--**	**0**	**8**	**0**	**0**	**1**	**0**	**--**	**--**	**--**	**--**	**--**	**--**	**0**	**1**	**0**	**0**	**0**	**0**
SBS 4	Diver 1	--	--	--	0	13	0	0	23	0	0	8	0	0	10	0	0	5	0	--	--	--
	Diver 2	--	--	--	--	--	--	0	24	0	--	--	--	--	--	--	0	3	0	--	--	--
	Diver 3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0	3	0	--	--	--
	Diver 4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Mean	**--**	**--**	**--**	**0**	**13**	**0**	**0**	**24**	**0**	**0**	**8**	**0**	**0**	**10**	**0**	**0**	**4**	**0**	**--**	**--**	**--**
	stdev	**--**	**--**	**--**	**--**	**--**	**--**	**0**	**1**	**0**	**--**	**--**	**--**	**--**	**--**	**--**	**0**	**1**	**0**	**--**	**--**	**--**

Appendix 9. Number of salmonids observed per visit from dive counts in the Shasta River at sites on the Hole in the Ground Ranch in 2008.

Site		13-May		27-May		11-Jun		24-Jun		8-Jul		21-Jul		6-Aug	
		coho	steelhead	coho	steelhead	coho	steelhead	coho	steelhead	coho	steelhead	coho	steelhead	coho	steelhead
	Diver 1	0	45	0	38	0	50	0	20	0	24	0	0	--	--
	Diver 2	0	47	0	30	1	58	0	0	0	13	0	1	--	--
	Diver 3	0	39	0	29	--	--	0	30	0	24	0	0	--	--
	Mean	**0**	**44**	**0**	**32**	**1**	**54**	**0**	**17**	**0**	**20**	**0**	**0**	--	--
HIG 1	**std**	**0**	**4.2**	**0.0**	**4.9**	**0.7**	**5.7**	**0.0**	**15.3**	**0.0**	**6.4**	**0.0**	**0.6**	**--**	**--**
	Diver 1	0	17	1	24	0	9	0	1	0	3	0	5	--	--
	Diver 2	0	0	16	5	0	11	0	4	0	5	0	4	--	--
	Diver 3	0	15	0	31	--	--	0	0	0	4	0	0	--	--
	Mean	**0**	**11**	**6**	**20**	**0**	**10**	**0**	**2**	**0**	**4**	**0**	**3**	--	--
HIG 2	**std**	**0**	**9.3**	**9.0**	**13.5**	**0.0**	**1.4**	**0.0**	**2.1**	**0.0**	**1.0**	**0.0**	**2.6**	**--**	**--**
	Diver 1	--	--	20	3	23	3	15	3	16	1	13	3	18	4
	Diver 2	--	--	19	1	26	3	0	0	10	1	20	5	12	9
	Diver 3	--	--	19	3	--	--	5	2	27	0	16	2	19	5
	Mean	--	--	**19**	**2**	**25**	**3**	**7**	**2**	**18**	**1**	**16**	**3**	**16**	**6**
HIG 3	**std**	**--**	**--**	**0.6**	**1.2**	**2.1**	**0.0**	**7.6**	**1.5**	**8.6**	**0.6**	**3.5**	**1.5**	**3.8**	**2.6**
	Diver 1	--	--	9	2	6	4	9	7	5	5	9	8	6	11
	Diver 2	--	--	9	1	3	2	9	10	2	10	5	4	3	5
	Diver 3	--	--	7	2	--	--	12	5	3	6	1	9	5	4
	Mean	--	--	**8**	**2**	**5**	**3**	**10**	**7**	**3**	**7**	**5**	**7**	**5**	**7**
HIG 4	**std**	**--**	**--**	**1.2**	**0.6**	**2.1**	**1.4**	**1.7**	**2.5**	**1.5**	**2.6**	**4.0**	**2.6**	**1.5**	**3.8**
	Diver 1	--	--	--	--	13	0	17	0	15	0	15	0	19	0
	Diver 2	--	--	--	--	26	0	8	2	7	3	5	0	27	0
	Diver 3	--	--	--	--	--	--	14	0	17	0	12	0	18	2
	Mean	--	--	--	--	**20**	**0**	**13**	**1**	**13**	**1**	**11**	**0**	**21**	**1**
HIG 5	**stdev**	**--**	**--**	**--**	**--**	**9.2**	**0.0**	**4.6**	**1.2**	**5.3**	**1.7**	**5.1**	**0.0**	**4.9**	**1.2**

Appendix 10: Nelson Ranch Salmonid Catches

Nelson Ranch RST and fyke salmonid catch by age class 2008, 2009. Mortalities are included in totals and indicated in parentheses.

2008 Salmonid Catch for Nelson Ranch Fykes by Julian Week (JW)

JW	Dates	Days Set	Fyke Days	Steelhead				Coho		Chinook
				0+	1+	2+	3+	0+	1+	0+
9	2/26-3/4	3	3		1	11		1	1	3
10	3/5-3/11	2	2		2	2		6 (1)		5
11	3/12-3-18	1	1					3		4
12	3/19-3/25	2	2					2		3
14	4/2 - 4/8	2	2			1				
15	4/9 - 4/15	3	4	3	1	4		9		2
16	4/16 - 4/22	2	6	2	1	6		40 (2)		4
17	4/23 - 4/29	2	6	3 (1)	1	2		54		4 (1)
18	4/30 - 5/6	3	9	6	3	1	1	70 (1)		3
19	5/7 - 5/13	4	12	23		2		94		16
20	5/14 - 5/20	7	21	69 (1)	3 (1)	5	2	676 (8)	1	28
21	5/21 - 5/27	2	6	14				59		2
22	5/28 - 6/3	3	7	5		1		5		
23	6/4 - 6/10	5	15	17	2		1	12		1
24	6/11 - 6/17	4	12	14			1	5		
25	6/18 - 6/24	5	14	22		4		6		1
26	6/25 - 7/1	2	4	3	1	1		4		
27	7/2 - 7/8	1	1	3				2		
28	7/9 - 7/15	1	2	2	1			1		
Totals		**54**	**129**	**186 (2)**	**16 (1)**	**40**	**5**	**1049 (12)**	**2**	**76 (1)**
				247 (3)				**1051 (12)**		**76 (1)**

Appendix 10 (cont): Nelson Ranch Salmonid Catches

2008 Salmonid Catch for Nelson Ranch RST by Julian Week (JW)										
JW	Dates	Days Set	Steelhead				Coho		Chinook	
			0+	1+	2+	3+	0+	1+	0+	1+
2	1/8 - 1/14	1								
3	1/15 - 1/21	3		1					46 (1)	
4	1/22 - 1/28	4			1				61	
5	1/29 - 2/4	2		1					23	
7	2/12 - 2/18	3							63 (1)	
8	2/19 - 2/25	3		1			1	1	21	2
9	2/26 - 3/4	3		2 (1)			14		84	
10	3/5 - 3/11	3		1	1		22		61 (1)	
11	3/12 - 3/18	2	1	1	1		7		29 (1)	
12	3/19 - 3/25	5	27	1	1		37		92	
13	3/26 - 4/1	3	8				8		15	
14	4/2 - 4/8	4	18	2	2		11		80	
15	4/9 - 4/15	5	23	2	2		5		197 (2)	
16	4/16 - 4/22	4	33	5	2		11		107	
17	4/23 - 4/29	5	45	4			5		22	
18	4/30 - 5/6	4	84	1			1		20	
19	5/7 - 5/13	4	185 (5)				10		21	
20	5/14 - 5/20	7	375	3		1	116 (1)	3	46	
21	5/21 - 5/27	4	350 (1)		1	1	9		1	
22	5/28 - 6/3	5	178 (3)				4			
23	6/4 - 6/10	5	360 (4)				6	1	1	
24	6/11 - 6/17	4	347	1			4		1	
25	6/18 - 6/24	4	123				2			
26	6/25 - 7/1	4	79				1			
27	7/2 - 7/8	1	24						1	
28	7/9 - 7/15	1	12							
Totals		**93**	**2272 (13)**	**26 (1)**	**11**	**2**	**274 (1)**	**5**	**992 (6)**	**2**
			2311 (14)				**279 (1)**		**994 (2)**	

Appendix 10 (cont): Nelson Ranch Salmonid Catches

2009 Salmonid Catch for Nelson Ranch Fykes by Julian Week (JW)									
JW	Dates	Days Set	Fyke Days	Steelhead				Coho	Chinook
				0+	1+	2+	3+	1+	0+
8	2/19 - 2/25	1	2		1	1			1
13	3/26 - 4/1	2	6		3	10	2	5	6
14	4/2 - 4/8	1	3			4	1		
15	4/9 - 4/15	2	6	2		2		1	3
16	4/16 - 4/22	3	9	4	2	10	1	1	4
17	4/23 - 4/29	2	6	3	1	4	2		1
18	4/30 - 5/6	1	3	5	1	3	1		
19	5/7 - 5/13	4	12	20		5		1	
20	5/14 - 5/20	3	7	33 (1)	1(1)			1	1 (1)
21	5/21 - 5/27	3	8	30	5	1	4		3
22	5/28 - 6/3	2	6	20	1		2		
23	6/4 - 6/10	2	2	19 (2)	4	1			
24	6/11 - 6/17	2	2	8 (1)	3	1	4		
25	6/18 - 6/24	3	3	11		3	1		
26	6/25 - 7/1	2	2	8	1	1	1		
27	7/2 - 7/8	2	2	4		3	2		1
28	7/9 - 7/15	2	2	10		5	1		
29	7/16 - 7/22	2	2	7		5			
Totals		**39**	**83**	**184 (4)**	**23 (1)**	**59**	**22**	**9**	**19 (1)**
				288 (5)				**9**	**19 (1)**

Appendix 10 (cont): Nelson Ranch Salmonid Catches

2009 Salmonid Catch for Nelson Ranch RST by Julian Week									
JW	Dates	Days Set	Steelhead				Coho	Chinook	
			0+	1+	2+	3+	1+	0+	1+
8	2/19 - 2/25	1		2				30	1
13	3/26 - 4/1	2	3		3			75 (1)	
14	4/2 - 4/8	3	15		4		1	61	
15	4/9 - 4/15	2	2		3			21	
16	4/16 - 4/22	3	53	4	7	1	1	119	
17	4/23 - 4/29	1	45					7	
18	4/30 - 5/6	2	55				8	8	
19	5/7 - 5/13	3	80 (1)		1		2	58 (1)	
20	5/14 - 5/20	3	107 (1)	1	1		1	42	
21	5/21 - 5/27	3	237 (4)					19	
22	5/28 - 6/3	2	98						
23	6/4 - 6/10	3	93		1			2	
24	6/11 - 6/17	3	197 (1)						
25	6/18 - 6/24	3	90 (1)						
26	6/25 - 7/1	2	30						
27	7/2 - 7/8	1	6						
28	7/9 - 7/15	2	31					1	
29	7/16 - 7/22	1	6						
Totals		**40**	**1148 (8)**	**7**	**20**	**1**	**13**	**443 (2)**	**1**
			1176 (8)				**13**	**444 (2)**	

Appendix 11: Quality Control

Results of tagged fish held overnight for evaluation of tagging mortality and tag loss at Nelson Ranch (RM32) in the spring and early summer of 2008.

Tagged Coho Held 24 Hours				
Date	**Held**	**Mortality**	**Shed Tag**	**Location**
4/17/08	1	0	0	RST
4/28/08	1	1	0	RST
5/16/08	12	0	0	RST
5/18/08	14	0	0	RST
5/19/08	13	0	0	RST
5/20/08	6	0	0	RST
5/20/08	6	0	0	Fykes
5/21/08	8	0	0	Fykes
5/21/08	4	0	0	RST
5/22/08	1	0	0	RST
5/29/08	1	0	0	RST
6/2/08	2	0	0	RST
6/4/08	1	0	0	RST
6/5/08	3	0	0	RST
6/6/08	2	0	0	RST
6/10/08	1	0	0	RST
6/11/08	1	0	0	RST
6/12/08	1	0	0	RST
6/13/08	1	0	0	RST
6/17/08	1	0	0	RST
6/17/08	3	0	0	Fykes
6/20/08	1	0	0	RST
Total	**84**	**1**	**0**	

Appendix 12: Antenna system locations and dates of operation.

Antenna System Operation Dates			
Location	**Description**	**Installation Date**	**Removal Date**
RM 0	Shasta Rivers confluence with the Klamath River	2/28/08	NA
RM 15	Meamber Ranch	5/3/08	NA
RM 26	Lower Nelson Ranch	4/11/08	10/5/2008
RM 32	Upper Nelson Ranch downstream of RST	4/6/08	NA
RM 32.1	Upper Nelson Ranch upstream fyke nets	9/24/08	2/16/2009
RM 32.9	SBS dive site 1	4/17/08	7/3/2008
RM 35	100 yards downstream of HIG dive site 1	9/24/08	NA
RM 36	HIG dive site 3	6/3/08	6/9/2009
RM 36.8	100 yards downstream of HIG dive site 5	7/1/08	NA
Big Springs Creek RM 2.6	Water wheel structure	8/7/08	11/20/2008
Big Springs Outfall	Big Springs outfall	8/7/08	NA
Parks Creek RM 0	Parks Creek 100 yards upstream from confluence with the Shasta River	10/29/08	NA
Parks Creek RM 4	Dukes Ranch	2/27/09	NA
Kettle Springs	Kettle Springs outfall	8/6/08	NA

Appendix 13. Nelson Ranch tagged coho upstream detections.
Detection histories of BY2007 coho tagged at Nelson Ranch (RM32) in the spring and early summer of 2008 that were later encountered at upstream locations. Individuals are arranged by detection history category and then tagging date with those individuals included in more than one category displayed at the end. Each individual is presented with tagging information on the fist line, including PIT tag number, date and FL at tagging followed by a chronological list of encounters. The first and last encounter at each location is displayed, if greater than one week apart.

Detection Histories of Nelson Ranch (RM 32) Spring/Summer 2008 Tagged BY2007 Coho Later Encountered Upstream			
PIT	Location	Date	FL (mm)
985161001010158	RM 32	4/29/08	62
	RM 36	6/8/08	
	RM 0	4/16/09	
985161001019021	RM 32	5/2/08	67
	RM 36.8	9/26/08	
	RM 36.8	4/10/09	
	RM 36	4/21/09	
	RM 35 Down	4/22/09	
985161000039518	RM 32	5/3/08	57
	RM 36.8	4/19/09	
985161000029814	RM 32	5/8/08	60
	RM 36	6/1/08	
985121003614157	RM 32	5/13/08	60
	RM 36.8	12/21/08	
	RM 36.8	4/8/09	
985161001305531	RM 32	5/16/08	62
	RM 36	6/3/08	
	RM 36.8	4/16/09	
985161000040928	RM 32	5/16/08	66
	RM 36	6/3/08	
985161000967825	RM 32	5/16/08	60
	RM 36	6/1/08	
	RM 36.8	6/14/08	
985121003014496	RM 32	5/17/08	60
	RM 36	6/5/08	

Appendix 13 (cont): Nelson Ranch tagged coho upstream detections.

PIT	Location	Date	FL (mm)
985121003671384	RM 32	5/17/08	57
	RM 36	6/7/08	
	RM 36.8	1/1/09	
	RM 36.8	2/14/09	
985121003610197	RM 32	5/18/08	57
	RM 36	6/13/08	
985121003610721	RM 32	5/18/08	64
	RM 36	5/30/08	
	RM 36.8	4/21/09	
	RM 36	4/22/09	
	RM 35 Down	4/22/09	
985161001298321	RM 32	5/20/08	62
	RM 36	6/24/08	
	RM 36.8	6/26/08	
985121003610895	RM 32	5/21/08	62
	RM 36	5/28/08	
	RM 36.8	4/7/09	
	RM 36	4/17/09	
985121003621512	RM 32	5/22/08	76
	RM 36	6/19/08	
	RM 36	4/22/09	
	RM 35 down	5/1/09	
985121003669538	RM 32	6/4/08	85
	RM 36	6/15/08	
	RM 36	4/15/09	
	RM 35 Down	4/16/09	
	RM 0	4/19/09	
985161001298907	RM 32	6/6/08	87
	RM 36	6/9/08	
	RM 36.8	2/26/09	
	RM 36.8	4/20/09	
	RM 36	4/21/09	
	RM 35 Down	5/3/09	
	RM 0	5/6/09	

Appendix 13 (cont): Nelson Ranch tagged coho upstream detections.

PIT	Location	Date	FL (mm)
985161000041444	RM 32	5/16/08	59
	Parks RM 0 Down	4/11/09	
	RM 0	4/14/09	
985121003611405	RM 32	5/18/08	66
	Parks RM 0 Down	3/18/09	
	RM 0	4/21/09	
985121003681207	RM 32	5/18/08	59
	Parks RM 0	4/12/09	
	RM 0	4/17/09	
985121003666742	RM 32	5/18/08	62
	Parks RM 0 Down	3/13/09	
	RM 0	3/22/09	
985121003617070	RM 32	5/22/08	64
	Parks RM 0 Down	4/21/09	
	RM 0	4/25/09	
985121003667410	RM 32	6/19/08	69
	Parks RM 0	3/31/09	
	RM 0	4/8/09	
985161001023413	RM 32	4/29/08	59
	Parks RM 4 Down	4/19/09	
	Parks RM 0	4/20/09	
	RM 0	4/23/09	
985121003015444	RM 32	5/17/08	59
	Parks RM 4	3/28/09	
	Parks RM 0	3/29/09	
	RM 0	4/10/09	
985121003670705	RM 32	5/19/08	59
	Parks RM 4 Down	4/7/09	
	Parks RM 0 Down	4/13/09	
	RM 0	4/16/09	

Appendix 13 (cont): Nelson Ranch tagged coho upstream detections.

PIT	Location	Date	FL (mm)
985121003617899	RM 32	5/21/08	56
	Parks RM 4	4/9/09	
	Parks RM 0	4/11/09	
985121003671350	RM 32	5/17/08	62
	Big Spring Outfall	8/22/08	
985121003619167	RM 32	5/18/08	59
	Big Spring Outfall	8/12/08	
	Big Spring Outfall	8/25/08	
	RM 0	4/13/09	
985161000040924	RM 32	5/20/08	63
	Big Spring Outfall	8/29/08	
	Big Spring Outfall	2/19/09	
985121003611602	RM 32	5/13/08	60
	Parks RM 0 Up	2/1/09	
	Parks RM 4	3/9/09	
	Parks RM 0 Down	3/13/09	
985161000978676	RM 32	5/16/08	56
	Parks RM 0	2/1/09	
	RM 0	4/16/09	
985161000967417	RM 32	5/20/08	58
	Parks RM 0	10/28/08	
	RM 0	4/15/09	
985121003629409	RM 32	5/15/08	55
	Kettle Springs	11/30/08	
985161000042094	RM 32	5/9/08	56
	RM 35	11/8/08	
	RM 36	1/13/09	

Appendix 13 (cont): Nelson Ranch tagged coho upstream detections.

PIT	Location	Date	FL (mm)
985161001299327	RM 32	5/16/08	58
	RM 35	9/25/08	
	RM 35 Down	3/17/09	
	RM 0	3/20/09	
985121003669351	RM 32	5/17/08	59
	RM 35	12/26/08	
985121003670704	RM 32	5/17/08	56
	RM 35	11/4/08	
985121003680853	RM 32	5/17/08	56
	RM 35	12/26/08	
985121003619464	RM 32	5/18/08	56
	RM 35 Up	11/3/08	
	RM 35 Down	12/21/08	
985161000971148	RM 32	5/19/08	60
	RM 35	11/1/08	
	RM 35	4/8/09	
	RM 0	4/11/09	
985121003617928	RM 32	5/20/08	59
	RM 35	10/19/08	
985121003621133	RM 32	5/15/08	65
	Big Spring Outfall	8/21/08	
	Parks RM 0 Up	1/9/09	
	Parks RM 4 Down	4/4/09	
	Parks RM 0 Down	4/8/09	
	RM 0	4/15/09	
985121003671814	RM 32	5/17/08	62
	RM 35	12/19/08	
	Kettle Springs	12/22/08	
	Parks RM 0	4/5/09	
	RM 0	4/8/09	

Appendix 13 (cont): Nelson Ranch tagged coho upstream detections.

PIT	Location	Date	FL (mm)
985161000044556	RM 32	5/20/08	61
	RM 35 Up	10/21/08	
	RM 35 Down	10/23/08	
	Kettle Springs	11/26/08	
	Parks RM 4	4/12/09	
	Parks RM 0 Down	4/13/09	
985121004103162	RM 32	5/17/08	60
	RM 35 Up	11/29/08	
	RM 35 Down	12/20/08	
	Kettle Springs	12/22/08	
985161000042511	RM 32	5/20/08	58
	RM 35	11/28/08	
	Parks RM 0 Down	2/20/09	
	RM 0	5/2/09	
985161000977277	RM 32	5/20/08	58
	RM 35 Up	10/31/08	
	RM 35 Down	11/19/08	
	Parks RM 0	3/18/09	
	RM 0	4/13/09	

Appendix 14: Fall Nelson Upstream Hits

Detection histories of BY2007 coho tagged at Nelson Ranch (RM 32) in the fall of 2008 that were later encountered at upstream locations. Each individual is presented with tagging information on the fist line, including PIT tag number, date and FL at tagging followed by a chronological list of encounters. The first and last encounter at each location is displayed, if greater than one week apart.

Detection Histories of Nelson Ranch Fall 2008 Tagged BY2007 Coho Later Encountered Upstream

PIT	Station	Date	FL (mm)
985121003662214	RM 32	10/17/08	102
	Parks RM 0	4/13/09	
	RM 0	4/16/09	
985121003669242	RM 32	10/22/08	113
	Parks RM 0	10/27/08	
985121003638990	RM 32	10/24/08	106
	RM 35 Up	10/31/08	
	RM 36	1/12/09	
	RM 36	3/26/09	
	RM 35 Down	4/14/09	
	RM 0	4/17/09	
985121003662436	RM 32	10/22/08	99
	Kettle Springs	11/28/08	
	Parks RM 0 Down	3/18/09	
	RM 0	4/24/09	

Appendix 15: HIG 3, HIG 5 Detection Histories

Detection histories of BY2007 tagged in the HIG 3-5 (RM 36-36.8) area that were detected at least one week after tagging. Also includes individuals that were tagged at Nelson Ranch (RM 32) that were later encountered in the RM 36-36.8 area. Each individual is presented with tagging information on the fist line, including PIT tag number, date and FL at tagging followed by a chronological list of encounters. The first and last encounter at each location is displayed, if greater than one week apart.

Detection Histories of HIG 3 and HIG 5 (RM 36 and 36.8) 2008 Tagged BY2007 Coho

PIT	Location	Date	FL (mm)
985121003668232	RM 36.8	6/11/08	74
	RM 36.8	2/23/09	
	RM 36	3/31/09	
	RM 36	4/24/09	
	RM 35 Down	4/28/09	
	RM 15	4/30/09	
985121003680652	RM 36.8	6/18/08	75
	RM 36.8	3/31/09	
	RM 36	4/1/09	
	RM 35 Down	4/10/09	
	RM 32	4/11/09	
	RM 15	4/13/09	
	RM 0	4/14/09	
985121003668977	RM 36.8	6/18/08	73
	RM 36.8	4/13/09	
	RM 35	4/23/09	
	RM 0	4/26/09	
985121003670582	RM 36.8	6/25/08	112
	RM 36.8	4/11/09	
	RM 36	4/17/09	
	RM 35 Down	5/3/09	
	RM 32	5/4/09	
	RM 15	5/5/09	
	RM 0	5/6/09	
985121003596145	RM 36.8	8/27/08	97
	RM 36.8	4/10/09	
	RM 36	4/22/09	
	RM 36	5/5/09	
	RM 35 Down	5/6/09	
	RM 0	5/9/09	

Appendix 15 (cont): HIG 3, HIG 5 Detection Histories

PIT	Location	Date	FL (mm)
985121003671402	RM 36.8	9/3/08	90
	RM 36.8	4/12/09	
	RM 36	4/23/09	
	RM 36	5/5/09	
	RM 35 Down	5/6/09	
	RM 15	5/8/09	
985121003670843	RM 36.8	9/3/08	88
	RM 36.8	4/17/09	
	RM 36	4/22/09	
	RM 35 Down	4/22/09	
	RM 15	4/23/09	
	RM 0	4/25/09	
985121003659473	RM 36.8	9/3/08	73
	RM 36.8	4/18/09	
	RM 35 Down	4/27/09	
	RM 0	5/1/09	
985121003668543	RM 36.8	9/3/08	102
	RM 36.8	4/10/09	
	RM 36	4/22/09	
	RM 35 Down	4/27/09	
	RM 0	4/30/09	
985121003669381	RM 36.8	9/3/08	83
	RM 36.8	4/21/09	
	RM 36	4/22/09	
	RM 36	5/10/09	
	RM 35 Down	5/14/09	
	RM 0	5/17/09	
985121003670285	RM 36.8	9/3/08	90
	RM 36.8	4/20/09	
	RM 36	4/21/09	
	RM 35 Down	4/22/09	
	RM 32	4/22/09	
	RM 0	4/26/09	
985121003667304	RM 36.8	9/3/08	91
	RM 36.8	2/23/09	
	RM 35	5/6/09	
	RM 32	5/7/09	
	RM 0	5/9/09	

Appendix 15 (cont): HIG 3, HIG 5 Detection Histories

PIT	Location	Date	FL (mm)
985121003671660	RM 36.8	9/3/08	81
	RM 36.8	4/11/09	
	RM 36	4/15/09	
	RM 35 Down	4/21/09	
	RM 32	4/22/09	
	RM 0	4/24/09	
985121003671777	RM 36.8	9/9/08	95
	RM 36.8	3/28/09	
	RM 36	4/21/09	
	RM 35 Down	4/23/09	
	RM 0	4/26/09	
985121003671209	RM 36.8	9/9/08	90
	RM 36.8	4/11/09	
	RM 36	4/15/09	
	RM 35 Down	4/23/09	
	RM 15	4/24/09	
	RM 0	4/27/09	
985121003659393	RM 36.8	9/9/08	85
	RM 36.8	4/10/09	
	RM 35	4/24/09	
	RM 0	4/27/09	
985121003667739	RM 36.8	9/9/08	97
	RM 36.8	4/10/09	
	RM 35 Down	5/1/09	
	RM 32	5/1/09	
	RM 0	5/4/09	
985121003660916	RM 36.8	9/9/08	88
	RM 36.8	4/10/09	
	RM 36	4/16/09	
	RM 35 Down	4/21/09	
	RM 32	4/22/09	
	RM 15	4/23/09	
	RM 0	4/25/09	

Appendix 15 (cont): HIG 3, HIG 5 Detection Histories

PIT	Location	Date	FL (mm)
985121003669388	RM 36.8	10/1/08	95
	RM 36.8	12/20/09	
	RM 36	2/11/09	
	RM 36	4/10/09	
	RM 35 Down	4/24/09	
	RM 15	4/26/09	
	RM 0	4/27/09	
985121003683418	RM 36.8	10/22/08	97
	RM 36.8	4/21/09	
	RM 36	5/6/09	
	RM 35 Down	5/11/09	
	RM 32	5/12/09	
	RM 0	5/15/09	
985121004101777	RM 36.8	10/22/08	87
	RM 36.8	4/4/09	
	RM 36	4/21/09	
	RM 35 Down	4/22/09	
	RM 0	4/25/09	
985121003659921	RM 36.8	10/22/08	100
	RM 36.8	4/13/09	
	RM 36	4/22/09	
	RM 36	5/5/09	
	RM 35 Down	5/6/09	
	RM 0	5/10/09	
985121003671557	RM 36.8	10/22/08	87
	RM 36.8	4/11/09	
	RM 36	4/13/09	
	RM 36	5/5/09	
	RM 35 Down	5/6/09	
	RM 0	5/8/09	
985121003680623	RM 36.8	10/22/08	88
	RM 36.8	4/21/09	
	RM 36	5/10/09	
	RM 35 Down	5/14/09	
	RM 32	5/14/09	
	RM 0	5/17/09	

Appendix 15 (cont): HIG 3, HIG 5 Detection Histories

PIT	Location	Date	FL (mm)
985121003660069	RM 36.8	10/22/08	91
	RM 36.8	4/21/09	
	RM 36	4/22/09	
	RM 35 Down	4/23/09	
	RM 0	4/26/09	
985121003660673	RM 36.8	10/22/08	97
	RM 36.8	3/26/09	
	RM 36	4/22/09	
	RM 35 Down	4/22/09	
	RM 32	4/23/09	
	RM 0	4/26/09	
985121003661529	RM 36.8	10/22/08	90
	RM 36.8	4/11/09	
	RM 36	4/22/09	
	RM 35 Down	4/24/09	
	RM 15	4/27/09	
	RM 0	4/29/09	
985121003667465	RM 36.8	12/10/08	94
	RM 36.8	3/27/09	
	RM 36	4/21/09	
	RM 35 Down	5/5/09	
	RM 32	5/5/09	
	RM 0	5/7/09	
985121003668602	RM 36.8	12/10/08	105
	RM 36.8	4/15/09	
	RM 35 Down	4/28/09	
	RM 32	4/29/09	
	RM 0	5/1/09	
985121003668865	RM 36.8	12/10/08	109
	RM 36.8	4/10//09	
	RM 36	4/16/09	
	RM 32	4/22/09	
	RM 0	4/24/09	
985161000975587	RM 36	6/3/08	72
	RM 36	3/17/09	
	RM 35 Down	3/25/09	
	RM 0	4/12/09	

Appendix 15 (cont): HIG 3, HIG 5 Detection Histories

PIT	Location	Date	FL (mm)
985121003611331	RM 36	6/3/08	70
	RM 36	5/6/09	
	RM 35 Down	5/7/09	
	RM 0	5/9/09	
985121003621937	RM 36	6/3/08	69
	RM 36	3/26/09	
	RM 35	4/25/09	
	RM 0	4/29/09	
985121003660670	RM 36	6/4/08	74
	RM 36.8	12/31/09	
	RM 36.8	4/3/09	
	RM 36	4/22/09	
	RM 35 Down	5/4/09	
	RM 32	5/5/09	
	RM 0	5/6/09	
985121003659719	RM 36	6/4/08	92
	RM 36	3/10/09	
	RM 35 Down	4/12/09	
	RM 15	4/14/09	
	RM 0	4/16/09	
985121003667974	RM 36	6/4/08	79
	RM 36	2/1/09	
	RM 35 Down	3/17/09	
	RM 0	3/20/09	
985121003668890	RM 36	11/12/08	99
	RM 36	1/14/09	
	RM 35 Down	4/8/09	
	RM 0	4/13/09	
985121003670192	RM 36	11/12/08	102
	RM 36	3/28/09	
	RM 35 Down	4/12/09	
	RM 15	4/14/09	
	RM 0	4/17/09	
985121003670470	RM 36	11/12/08	115
	RM 36	3/27/09	
	RM 35 Down	3/29/09	
	RM 32	3/29/09	

Appendix 15 (cont): HIG 3, HIG 5 Detection Histories

PIT	Location	Date	FL (mm)
985121003670407	RM 36	11/12/08	104
	RM 36	3/30/09	
	RM 35 Down	4/24/09	
	RM 0	4/26/09	
985121003662967	RM 36	11/12/08	110
	RM 36	3/27/09	
	RM 35 Down	4/2/09	
	RM 0	4/11/09	
985121003670747	RM 36	11/12/08	115
	RM 36	3/28/09	
	RM 35 Down	4/14/09	
	RM 0	4/19/09	
985121003683501	RM 36	11/12/08	108
	RM 36	4/10/09	
	RM 35 Down	4/17/09	
	RM 15	4/19/09	
	RM 0	4/20/09	
985121003014359	RM 36	11/12/08	102
	RM 36	12/11/08	
	RM 35 Down	4/11/09	
	RM 0	4/17/09	
985121003680990	RM 36	11/12/08	105
	RM 36	4/30/09	
	RM 35 Down	5/4/09	
	RM 0	5/6/09	
985121003669522	RM 36	12/10/08	104
	RM 36	3/30/09	
	RM 35 Down	4/16/09	
	RM 0	4/19/09	
985121003669790	RM 36	12/10/08	102
	RM 35 Down	3/21/09	
	RM 0	3/24/09	
985121003670223	RM 36	12/10/08	110
	RM 36	4/1/09	
	RM 35 Down	5/6/09	
	RM 32	5/7/09	
	RM 0	5/9/09	

Appendix 15 (cont): HIG 3, HIG 5 Detection Histories

PIT	Location	Date	FL (mm)
985121003670370	RM 36	12/10/08	109
	RM 35 Down	4/22/09	
	RM 15	4/23/09	
	RM 0	4/24/09	
985121003670375	RM 36	12/10/08	110
	RM 36	3/28/09	
	RM 35 Down	4/19/09	
	RM 0	4/22/09	
985121003670797	RM 36	12/10/08	130
	RM 36	3/31/09	
	RM 35 Down	5/4/09	
	RM 0	5/6/09	
985121003662092	RM 36	12/10/08	100
	RM 36	2/20/09	
	RM 35 Down	4/16/09	
	RM 0	4/21/09	
985121003662635	RM 36	12/10/08	112
	RM 36	3/29/09	
	RM 35	4/24/09	
	RM 15	4/25/09	
	RM 0	4/27/09	
985121003666176	RM 36	12/10/08	117
	RM 36	3/25/09	
	RM 35 Down	4/11/09	
	RM 32	4/11/09	
	RM 15	4/12/09	
	RM 0	4/14/09	
985121003659162	RM 36	12/10/08	127
	RM 36	2/4/09	
	RM 35 Down	4/16/09	
	RM 15	4/18/09	
	RM 0	4/19/09	
985121003659218	RM 36	12/10/08	110
	RM 36	1/18/09	
	RM 35 Down	3/26/09	
	RM 0	4/10/09	

Appendix 15 (cont): HIG 3, HIG 5 Detection Histories

PIT	Location	Date	FL (mm)
985121003659264	RM 36	12/10/08	109
	RM 36	3/31/09	
	RM 35 Down	4/16/09	
	RM 32	4/16/09	
	RM 0	4/19/09	
985121003659343	RM 36	12/10/08	113
	RM 36	3/17/09	
	RM 35 Down	3/25/09	
	RM 0	3/27/09	
985121003667493	RM 36	12/10/08	109
	RM 36	2/15/00	
	RM 35 Down	4/1709	
	RM 15	4/18/09	
	RM 0	4/20/09	
985121003668359	RM 36	12/10/08	121
	RM 36	3/28/09	
	RM 35 Down	4/6/09	
	RM 0	4/14/09	
985121003668468	RM 36	12/10/08	98
	RM 36	3/17/09	
	RM 35	3/28/09	
	RM 0	4/7/09	
985121003668586	RM 36	12/10/08	113
	RM 36	4/21/09	
	RM 35 Down	5/6/09	
	RM 32	5/6/09	
	RM 0	5/8/09	
985121003668862	RM 36	12/10/08	110
	RM 36	4/16/09	
	RM 35 Down	5/4/09	
	RM 0	5/6/09	
985121003659426	RM 36	12/10/08	120
	RM 36	3/20/09	
	RM 35 Down	5/8/09	
	RM 0	5/11/09	

Appendix 15 (cont): HIG 3, HIG 5 Detection Histories

PIT	Location	Date	FL (mm)
985121003680441	RM 36	12/10/08	120
	RM 35 Down	4/6/09	
	RM 15	4/7/09	
	RM 0	4/12/09	
985121003681631	RM 36	12/10/08	103
	RM 36	1/5/09	
	RM 35 Down	4/5/09	
	RM 15	4/11/09	
	RM 0	4/13/09	
985121003681966	RM 36	12/10/08	112
	RM 36	5/3/09	
	RM 35 Down	5/6/09	
	RM 15	5/8/09	
	RM 0	5/9/09	
985121004103563	RM 36	12/10/08	113
	RM 36	3/24/09	
	RM 35 Down	4/16/09	
	RM 15	4/19/09	
	RM 0	4/20/09	
985121003671587	RM 36	12/10/08	100
	RM 36	3/6/09	
	RM 35 Down	4/17/09	
	RM 15	4/19/09	
985121003667272	RM 36	12/10/08	100
	RM 36	4/10/09	
	RM 35 Down	5/7/09	
	RM 15	5/8/09	
985161001010158	RM 32	4/29/08	62
	RM 36	6/8/08	
	RM 0	4/16/09	
985121003669538	RM 32	6/4/08	85
	RM 36	6/15/08	
	RM 36	4/15/09	
	RM 35 Down	4/16/09	
	RM 0	4/19/09	

Appendix 15 (cont): HIG 3, HIG 5 Detection Histories

PIT	Location	Date	FL (mm)
985161001298907	RM 32	6/6/08	87
	RM 36	6/9/08	
	RM 36.8	2/25/09	
	RM 36	4/21/09	
	RM 35 Down	5/3/09	
	RM 0	5/6/09	
985121003638990	RM 32	10/24/08	106
	RM 35 Up	10/31/09	
	RM 36	1/12/09	
	RM 36	3/26/09	
	RM 35 Down	4/14/09	
	RM 0	4/17/09	
985121003671630	RM 36.8	6/11/08	87
	RM 36.8	4/10/09	
	RM 36	4/22/09	
	RM 35 Down	4/18/09	
	RM 32	5/18/09	
985121004103122	RM 36.8	9/9/08	92
	RM 36.8	3/30/09	
	RM 35 Down	5/6/09	
985121003683707	RM 36.8	9/9/08	83
	RM 36.8	4/16/09	
	RM 36	4/22/09	
	RM 35 Down	5/4/09	
985121003671525	RM 36.8	9/9/08	80
	RM 36.8	4/10/09	
	RM 36	4/22/09	
	RM 35 Down	4/24/09	
985121003668844	RM 36.8	9/9/08	87
	RM 36.8	4/22/09	
	RM 36	4/23/09	
	RM 35 Down	5/7/09	
985121003667381	RM 36.8	10/1/08	92
	RM 36.8	4/6/09	
	RM 36	4/16/09	
	RM 35 Down	4/21/09	

Appendix 15 (cont): HIG 3, HIG 5 Detection Histories

PIT	Location	Date	FL (mm)
985121003671036	RM 36.8	10/22/08	98
	RM 36.8	2/23/09	
	RM 36	4/17/09	
	RM 35 Down	4/22/09	
985121003015485	RM 36.8	10/22/08	92
	RM 36.8	4/10/09	
	RM 36	4/23/09	
	RM 35 Down	4/24/09	
985121003681685	RM 36.8	12/10/08	116
	RM 36.8	4/2/09	
	RM 36	4/20/09	
	RM 35 Down	4/23/09	
985161000045916	RM 36	5/28/08	79
	RM 36	3/24/09	
	RM 35 Down	4/12/09	
985161000975454	RM 36	5/28/08	69
	RM 36.8	1/1/09	
	RM 36.8	3/20/09	
	RM 35 Down	5/5/09	
	RM 32	5/6/09	
985121003660743	RM 36	6/4/08	86
	RM 36	2/18/09	
	RM 35 Down	5/4/09	
985121003680370	RM 36	12/10/08	110
	RM 36	2/2/09	
	RM 35 Down	5/6/09	
985121003660271	RM 36	12/10/08	102
	RM 36	3/30/09	
	RM 35 Down	5/6/09	
	RM 32	5/7/09	
985121003659659	RM 36	12/10/08	109
	RM 36	5/6/09	
	RM 35 Down	5/6/09	

Appendix 15 (cont): HIG 3, HIG 5 Detection Histories

PIT	Location	Date	FL (mm)
985121003610721	RM 32	5/18/08	64
	RM 36	5/30/08	
	RM 36.8	4/21/09	
	RM 36	4/22/09	
	RM 35 Down	4/22/09	
985161001019021	RM 32	5/2/08	67
	RM 36.8	9/26/08	
	RM 36.8	4/10/09	
	RM 36	4/21/09	
	RM 35 Down	4/22/09	
985121003621512	RM 32	5/22/08	76
	RM 36	6/19/08	
	RM 36	4/22/09	
	RM 35 Down	5/1/09	
985121003682838	RM 36.8	6/4/08	74
	RM 36.8	4/13/09	
	RM 36	4/22/09	
985121003670560	RM 36.8	6/4/08	70
	RM 36.8	4/10/09	
985121003669532	RM 36.8	6/18/08	84
	RM 36.8	4/12/09	
	RM 36	4/22/09	
985121003683512	RM 36.8	6/18/08	78
	RM 36.8	4/19/09	
985121003684925	RM 36.8	6/25/08	84
	RM 36.8	3/20/09	
	RM 36	4/22/09	
985121003682121	RM 36.8	6/25/08	83
	RM 36.8	3/17/09	
	RM 36	3/19/09	
985121003671281	RM 36.8	6/25/08	78
	RM 36.8	5/4/09	
	RM 36	5/8/09	
985121003671553	RM 36.8	8/20/08	105
	RM 36.8	4/13/09	
	RM 36	4/16/09	

Appendix 15 (cont): HIG 3, HIG 5 Detection Histories

PIT	Location	Date	FL (mm)
985121003016223	RM 36.8	8/27/08	86
	RM 36.8	4/20/09	
985121003638937	RM 36.8	8/27/08	94
	RM 36.8	4/13/09	
	RM 36	4/21/09	
	RM 36	5/10/09	
985121003662803	RM 36.8	8/27/08	106
	RM 36.8	5/4/09	
985121003668841	RM 36.8	9/3/08	105
	RM 36.8	4/10/09	
	RM 36	4/17/09	
985121003659412	RM 36.8	9/3/08	79
	RM 36.8	4/10/09	
	RM 36	5/4/09	
985121003671569	RM 36.8	9/3/08	88
	RM 36.8	4/11/09	
	RM 36	5/5/09	
	RM 36	5/29/09	
985121003670815	RM 36.8	9/9/08	83
	RM 36.8	4/19/09	
	RM 36	4/22/09	
985121003671272	RM 36.8	9/9/08	104
	RM 36.8	4/20/09	
	RM 36	4/23/09	
985121003680433	RM 36.8	9/9/08	92
	RM 36.8	4/20/09	
	RM 36	4/22/09	
985121003661661	RM 36.8	9/9/08	106
	RM 36.8	4/18/09	
	RM 36	4/24/09	
985121003667151	RM 36.8	9/9/08	84
	RM 36.8	3/27/09	
	RM 36	4/22/09	
985121003659614	RM 36.8	9/9/08	94
	RM 36.8	4/1/09	

Appendix 15 (cont): HIG 3, HIG 5 Detection Histories

PIT	Location	Date	FL (mm)
985121003659654	RM 36.8	9/9/08	86
	RM 36.8	4/6/09	
	RM 36	4/22/09	
	RM 36	5/5/09	
985121003659092	RM 36.8	9/9/08	88
	RM 36.8	3/16/09	
	RM 36	3/22/09	
	RM 36	4/13/09	
985121003641484	RM 36.8	9/9/08	78
	RM 36.8	4/13/09	
985121003659279	RM 36.8	9/9/08	105
	RM 36.8	3/28/09	
	RM 36	5/5/09	
985121003641122	RM 36.8	10/22/08	96
	RM 36.8	3/17/09	
985121004105705	RM 36.8	10/22/08	94
	RM 36.8	4/15/09	
	RM 36	4/25/09	
985121003664315	RM 36.8	10/22/08	90
	RM 36.8	5/4/09	
	RM 36	5/5/09	
985121003680910	RM 36.8	10/22/08	98
	RM 36.8	4/4/09	
	RM 36	4/22/09	
985121003660933	RM 36.8	12/10/08	107
	RM 36.8	2/24/09	
	RM 36	4/17/09	
985121003670507	RM 36.8	12/10/08	95
	RM 36.8	12/23/08	
	RM 36	4/7/09	
985121003666330	RM 36.8	12/10/08	99
	RM 36.8	2/22/09	
	RM 36	4/22/09	
985121003659556	RM 36.8	12/10/08	119
	RM 36.8	4/10/09	

Appendix 15 (cont): HIG 3, HIG 5 Detection Histories

PIT	Location	Date	FL (mm)
985121003659721	RM 36.8	12/10/08	105
	RM 36.8	4/14/09	
985121003668671	RM 36.8	12/10/08	99
	RM 36.8	3/18/09	
	RM 36	4/22/09	
	RM 36	5/10/09	
985121003668799	RM 36.8	12/10/08	111
	RM 36.8	4/5/09	
985121003610895	RM 36	5/28/08	62
	RM 36.8	4/7/09	
	RM 36	4/17/09	
985121003614122	RM 36	6/3/08	80
	RM 36	4/16/09	
985121003621861	RM 36	6/3/08	78
	RM 36.8	9/24/08	
	RM 36.8	4/10/09	
	RM 36	5/4/09	
	RM 36	5/12/09	
985121003683006	RM 36	6/4/08	74
	RM 36.8	4/14/09	
	RM 36	4/22/09	
	RM 36	5/9/09	
985121003668776	RM 36	11/12/08	107
	RM 36	4/16/09	
985121003669899	RM 36	12/10/08	116
	RM 36	5/4/09	
985121003669713	RM 36	12/10/08	119
	RM 36	3/31/09	
985121004103218	RM 36	12/10/08	110
	RM 36	4/16/09	
985121003659809	RM 36	12/10/08	103
	RM 36	5/3/09	
985121003683997	RM 36	12/10/08	96
	RM 36	3/17/09	

Appendix 15 (cont): HIG 3, HIG 5 Detection Histories

PIT	Location	Date	FL (mm)
985121003660162	RM 36	12/10/08	107
	RM 36	5/9/09	
985121003670202	RM 36	12/10/08	107
	RM 36	3/17/09	
985121003610895	RM 32	5/21/08	62
	RM 36	5/28/08	
	RM 36.8	4/7/09	
	RM 36	4/17/09	
985121003671353	RM 36.8	6/18/08	80
	RM 36.8	8/29/08	
985121003670389	RM 36.8	8/20/08	104
	RM 36.8	2/25/09	
985121003671003	RM 36.8	8/27/08	87
	RM 36.8	12/17/09	
985121003668088	RM 36.8	9/3/08	78
	RM 36.8	12/25/08	
985121003659254	RM 36.8	9/3/08	103
	RM 36.8	9/7/09	
985121003663551	RM 36.8	9/9/08	100
	RM 36.8	12/19/08	
985121003663805	RM 36.8	9/9/08	92
	RM 36.8	1/22/09	
	RM 36	1/30/09	
985121003664053	RM 36.8	9/9/08	89
	RM 36.8	12/27/08	
985121003683970	RM 36.8	10/1/08	103
	RM 36.8	12/22/08	
985121003659557	RM 36.8	10/1/08	94
	RM 36.8	2/15/09	
985121003669420	RM 36.8	10/22/08	95
	RM 36.8	2/23/09	

Appendix 15 (cont): HIG 3, HIG 5 Detection Histories

PIT	Location	Date	FL (mm)
985121004101642	RM 36.8	10/22/08	104
	RM 36.8	1/22/09	
985121003671083	RM 36.8	12/10/08	103
	RM 36.8	2/25/09	
985121003666917	RM 36.8	12/10/08	99
	RM 36.8	2/7/09	
985161000971454	RM 36	5/28/08	71
	RM 36	2/5/09	
985121003617542	RM 36	6/3/08	71
	RM 36.8	7/14/08	
	RM 36.8	12/28/08	
985121003610234	RM 36	6/3/08	69
	RM 36	9/17/08	
985121003642005	RM 36	11/12/08	103
	RM 36	1/2/09	
985121003668007	RM 36	11/12/08	122
	RM 36	12/26/08	
985121003667405	RM 36	11/12/08	111
	RM 36	1/2/09	
985121003668196	RM 36	12/10/08	120
	RM 36	12/19/08	
985121003683428	RM 36	12/10/08	123
	RM 36	1/17/09	
985121003667300	RM 36	12/10/08	122
	RM 36	1/18/09	
985161000042094	RM 32	5/9/08	56
	RM 35	11/8/08	
	RM 36	1/13/09	
985121003671384	RM 32	5/17/08	57
	RM 36	6/7/08	
	RM 36.8	1/1/09	
	RM 36.8	2/14/09	

Appendix 15 (cont): HIG 3, HIG 5 Detection Histories

PIT	Location	Date	FL (mm)
985161001298321	RM 32	5/20/08	62
	RM 36	6/24/08	
	RM 36.8	6/26/08	
985121003610197	RM 32	5/18/08	57
	RM 36	6/31/09	
985121003619917	RM 36	6/3/08	91
	SRKM 43	6/6/08	
985121003669429	RM 36	12/10/08	114
	RM 36	12/23/09	
	RM 35 Down	12/25/08	

Appendix 16.
Detection histories of BY2007 coho tagged in the HIG 2 vicinity (RM 35.2) site. Each individual is presented with tagging information on the fist line, including PIT tag number, date and FL at tagging followed by a chronological list of encounters. The first and last encounter at each location is displayed, if greater than one week apart.

Detection Histories of HIG 2 (RM 35.2) 2008 Tagged BY2007 Coho

PIT	Station	Date	FL (mm)
985121003669407	RM 35.2	10/22/08	112
	RM 36	12/28/08	
	RM 36	3/30/09	
	RM 35 Down	4/14/09	
	RM 15	4/16/09	
	RM 0	4/19/09	
985121003669807	RM 35.2	12/2/08	98
	RM 35	12/16/08	
	RM 36	1/6/09	
	RM 36	3/28/09	
	RM 35 Down	4/15/09	
	RM 0	4/19/09	
985121003667449	RM 35.2	12/2/08	105
	RM 35 Down	4/10/09	
	RM 15	4/13/09	
	RM 0	4/19/09	
985121003668875	RM 35.2	9/9/08	101
	RM 35	12/24/09	
	RM 0	4/11/09	
985121003663267	RM 35.2	9/9/08	91
	RM 35 Down	12/20/08	
	RM 15	4/11/09	
	RM 0	4/19/09	
985121003659530	RM 35.2	10/22/08	92
	RM 35 Down	12/28/08	
	Parks RM 0 Down	4/11/09	
	RM 0	4/19/09	
985121003668633	RM 35.2	10/22/08	109
	RM 35 Down	4/12/09	
985121003660268	RM 35.2	12/2/08	115
	RM 36	2/3/09	
	RM 36	3/28/09	

Appendix 16 (cont): Detection Histories of HIG 2 (RM 35.2) 2008 Tagged BY2007 Coho

PIT	Station	Date	FL (mm)
985121003669398	RM 35.2	12/2/08	105
	RM 35 Down	12/20/08	
	Parks RM 0 Up	2/19/09	
985121003661223	RM 35.2	12/2/08	110
	RM 35 Down	12/20/09	
	Parks RM 0 Down	4/21/09	
985121003670732	RM 35.2	12/2/08	103
	RM 35 Down	12/3/08	
	Parks RM 0 Down	3/24/09	
	RM 15	4/5/09	
985121003683827	RM 35.2	10/22/08	113
	Parks RM 0 Down	3/17/09	
	RM 0	3/21/09	
985121003660129	RM 35.2	10/22/08	108
	RM 35 Down	12/16/08	
	Parks RM 0 Down	3/27/09	
	RM 15	4/7/09	
985121003670516	RM 35.2	12/2/08	114
	RM 35	12/25/08	
	RM 15	4/15/09	
985121003670799	RM 35.2	12/2/08	113
	RM 35 Down	12/6/08	
985121004105530	RM 35.2	9/9/08	112
	RM 35 Down	12/17/08	
985121003659610	RM 35.2	12/2/08	111
	RM 35 Down	12/28/08	
985121003671645	RM 35.2	12/2/08	109
985121003618132	RM 35.2	9/9/08	100
985121003671574	RM 35.2	12/2/08	118
985121003660690	RM 35.2	12/2/08	109
985121003717130	RM 35.2	12/2/08	121
985121003640950	RM 35.2	9/9/08	96

Appendix 17: BSOF detection histories

Detection histories of BY2007 coho tagged at Big Springs Creek outfall that were detected at least a month after tagging. Each individual is presented with tagging information on the fist line, including PIT tag number, date and FL at tagging followed by a chronological list of encounters. The first and last encounter at each location is displayed, if greater than one week apart.

Detection Histories of Big Springs Outfall 2008 Tagged BY2007 Coho			
PIT	Location	Date	FL (mm)
985121003667494	Big Springs Outfall	8/7/08	107
	RM 35	12/21/08	
	Parks RM 0	3/24/09	
	RM 0	4/5/09	
985121003670898	Big Springs Outfall	9/8/08	108
	Big Springs Outfall	11/21/08	
	Parks RM 0	4/19/09	
	RM 15	4/21/09	
	RM 0	4/24/09	
985121003669757	Big Springs Outfall	8/7/08	100
	Big Springs Outfall	11/24/08	
	Kettle Springs	11/29/08	
	Parks RM 0	3/18/09	
	RM 0	4/20/09	
985121003667342	Big Springs Outfall	9/8/08	102
	Big Springs Outfall	11/25/08	
	Kettle Springs	12/1/08	
	Parks RM 0	4/15/09	
	RM 15	4/16/09	
985121004105795	Big Springs Outfall	9/8/08	111
	Big Springs Outfall	11/24/08	
	Parks RM 0	3/18/09	
	RM 32	3/19/09	
	RM 0	4/20/09	
985121003671790	Big Springs Outfall	11/13/08	121
	Big Springs Outfall	11/27/08	
	RM 0	4/22/09	
985121003666957	Big Springs Outfall	9/8/08	108
	Big Springs Outfall	9/10/08	
	RM 15	4/18/09	
	RM 0	4/22/09	

Appendix 17 (cont.):Detection Histories of Big Springs Outfall 2008 Tagged BY2007 Coho

PIT	Location	Date	FL (mm)
985121003669535	Big Springs Outfall	11/13/08	132
	Big Springs Outfall	11/14/08	
	RM 15	4/24/09	
	RM 0	4/26/09	
985121003664721	Big Springs Outfall	11/13/08	127
	Big Springs Outfall	11/17/08	
	RM 0	4/13/09	
985121003667062	Big Springs Outfall	11/13/08	133
	Big Springs Outfall	11/21/08	
	RM 0	4/22/09	
985121003659253	Big Springs Outfall	11/13/08	119
	RM 0	3/28/09	
985121003642429	Big Springs Outfall	11/13/08	119
	Big Springs Outfall	11/21/08	
	RM 15	4/9/09	
	RM 0	4/13/09	150
985121003668652	Big Springs Outfall	9/8/08	110
	Big Springs Outfall	11/21/08	
	RM 15	4/3/09	
	RM 0	4/14/09	
985121003668882	Big Springs Outfall	9/8/08	102
	RM 0	4/15/09	
985121003639024	Big Springs Outfall	11/13/08	117
	RM 32	3/19/09	
	RM 0	3/20/09	
985121003670953	Big Springs Outfall	9/8/08	104
	Big Springs Outfall	9/10/08	
	RM 0	4/22/09	
985121003669302	Big Springs Outfall	9/8/08	106
	Big Springs Outfall	11/21/08	
	RM 15	4/23/09	
	RM 0	4/25/09	

Appendix 17 (cont.):Detection Histories of Big Springs Outfall 2008 Tagged BY2007 Coho

PIT	Location	Date	FL (mm)
985121003659133	Big Springs Outfall	9/8/08	105
	Big Springs Outfall	11/17/08	
	RM 0	4/23/09	
985121003662721	Big Springs Outfall	8/7/08	104
	Big Springs Outfall	8/14/08	
	RM 15	5/16/09	
	RM 0	5/18/09	
985121003681892	Big Springs Outfall	11/13/08	129
	Big Springs Outfall	11/16/08	
	RM 0	4/17/09	151
985121003670469	Big Springs Outfall	8/7/08	96
	RM 15	4/2/09	
	RM 0	4/5/09	
985121004100173	Big Springs Outfall	11/13/08	115
	Big Springs Outfall	11/17/08	
	RM 0	4/20/09	135
985121003668435	Big Springs Outfall	9/8/08	102
	Big Springs Outfall	9/10/08	
	RM 15	4/7/09	
	RM 0	4/19/09	
985121003669772	Big Springs Outfall	8/7/08	98
	Big Springs Outfall	8/9/08	
	RM 0	4/14/09	
985121003683597	Big Springs Outfall	11/13/08	118
	Big Springs Outfall	11/21/08	
	RM 15	2/26/09	
	RM 0	3/26/09	
985121003662040	Big Springs Outfall	9/8/08	104
	Big Springs Outfall	9/10/08	
	RM 15	1/20/09	
	RM 0	5/3/09	
985121003667747	Big Springs Outfall	11/13/08	121
	Big Springs Outfall	2/25/09	
	RM 15	4/9/09	
	RM 0	4/14/09	

Appendix 17 (cont.):Detection Histories of Big Springs Outfall 2008 Tagged BY2007 Coho

PIT	Location	Date	FL (mm)
985121003671312	Big Springs Outfall	9/8/08	103
	Big Springs Outfall	1/24/09	
	RM 32	4/6/09	
	RM 15	4/14/09	
	RM 0	4/21/09	
985121003659270	Big Springs Outfall	11/13/08	120
	Big Springs Outfall	2/20/09	
	RM 15	4/20/09	
	RM 0	4/20/09	149
985121003640649	Big Springs Outfall	9/8/08	110
	Big Springs Outfall	12/22/08	
	RM 15	4/10/09	
	RM 0	4/20/09	
985121003667389	Big Springs Outfall	9/8/08	113
	Big Springs Outfall	3/12/09	
	RM 0	4/20/09	164
985121003663668	Big Springs Outfall	11/13/08	117
	Big Springs Outfall	3/3/09	
	RM 15	4/3/09	
	RM 0	4/14/09	148
985121003668940	Big Springs Outfall	11/13/08	108
	Big Springs Outfall	3/20/09	
	RM 0	4/11/09	140
985121003667288	Big Springs Outfall	9/8/08	105
	Big Springs Outfall	11/17/08	
	RM 15	3/26/09	
985121003669449	Big Springs Outfall	9/8/08	109
	Big Springs Outfall	3/12/09	
	RM 15	3/15/09	
985121003668979	Big Springs Outfall	8/7/08	103
	Big Springs Outfall	11/21/08	
	RM 35	12/6/08	
985121003664116	Big Springs Outfall	8/7/08	105
	Big Springs Outfall	11/17/08	

Appendix 17 (cont.):Detection Histories of Big Springs Outfall 2008 Tagged BY2007 Coho

PIT	Location	Date	FL (mm)
985121003666518	Big Springs Outfall	8/7/08	105
	Big Springs Outfall	11/21/08	
985121003683737	Big Springs Outfall	8/7/08	95
	Big Springs Outfall	11/22/08	
985121003668973	Big Springs Outfall	9/8/08	110
	Big Springs Outfall	11/18/08	
985121003659464	Big Springs Outfall	9/8/08	103
	Big Springs Outfall	11/25/08	
985121003016000	Big Springs Outfall	9/8/08	99
	Big Springs Outfall	11/18/08	
985121003668385	Big Springs Outfall	9/8/08	102
	Big Springs Outfall	11/17/08	
985121003660876	Big Springs Outfall	8/7/08	97
	Big Springs Outfall	9/8/08	105
985121003667217	Big Springs Outfall	9/8/08	117
	Big Springs Outfall	11/20/08	
985121004102491	Big Springs Outfall	9/8/08	105
	Big Springs Outfall	11/25/08	
985121003670168	Big Springs Outfall	9/8/08	117
	Big Springs Outfall	11/18/08	
985121003668571	Big Springs Outfall	9/8/08	116
	Big Springs Outfall	11/21/08	
985121003671398	Big Springs Outfall	11/13/08	127
	Big Springs Outfall	1/20/09	
985121003680783	Big Springs Outfall	11/13/08	130
	Big Springs Outfall	1/26/09	
985121003667475	Big Springs Outfall	9/8/08	108
	Big Springs Outfall	12/25/08	
985121003668564	Big Springs Outfall	11/13/08	123
	Big Springs Outfall	2/26/09	

Appendix 17 (cont.):Detection Histories of Big Springs Outfall 2008 Tagged BY2007 Coho

PIT	Location	Date	FL (mm)
985121003715286	Big Springs Outfall	8/7/08	89
	Big Springs Outfall	1/25/09	
985121003670161	Big Springs Outfall	11/13/08	111
	Big Springs Outfall	3/6/09	

Appendix 18: Big Springs RM 1.5 tagged coho detection histories

Detection histories of BY2007 coho tagged at Big Springs Creek RM 1.5 that were later encountered. Each individual is presented with tagging information on the fist line, including PIT tag number, date and FL at tagging followed by a chronological list of encounters. The first and last encounter at each location is displayed, if greater than one week apart.

Detection Histories of Big Springs RM 1.5 2008 BY2007 Tagged Coho			
PIT	Location	Date	FL (mm)
985121003660837	Big Springs RM 1.5	12/5/08	126
	Parks RM 0 Up	1/21/09	
	Parks RM 0 Down	4/11/09	
	RM 0	4/21/09	
985121003664308	Big Springs RM 1.5	12/5/08	114
	Parks RM 0 Up	3/12/09	
	Parks RM 0 Down	3/21/09	
	RM 35 Up	3/21/09	
	RM 35 Down	4/16/09	
	RM 0	4/20/09	
985121003660232	Big Springs RM 1.5	12/5/08	110
	RM 0	3/19/09	
985121003666899	Big Springs RM 1.5	12/5/08	119
	RM 0	4/15/09	
985121003669537	Big Springs RM 1.5	12/5/08	111
	RM 0	3/28/09	
985121003670557	Big Springs RM 1.5	12/5/08	116
	RM 0	4/20/09	
985121003684775	Big Springs RM 1.5	12/5/08	111
	RM 0	4/14/09	
985121004105724	Big Springs RM 1.5	12/5/08	108
	RM 0	4/21/09	
985121003667479	Big Springs RM 1.5	12/5/08	109
	RM 15	4/19/09	
985121003681209	Big Springs RM 1.5	12/5/08	105
	RM 15	4/22/09	

Appendix 19: Kettle Springs tagged coho detection histories.

Detection histories of BY2007 coho tagged at Kettle Springs. Each individual is presented with tagging information on the fist line, including PIT tag number, date and FL at tagging followed by a chronological list of encounters. The first and last encounter at each location is displayed, if greater than one week apart.

Detection Histories of Kettle Springs 2008 Tagged BY2007 Coho

PIT	Location	Date	FL (mm)
985121003662983	Kettle Springs	8/26/08	101
	Kettle Springs	10/1/08	
	Parks RM 4	4/2/09	
	Parks RM 0 Down	4/8/09	
	RM 0	4/14/09	
985121003683778	Kettle Springs	8/6/08	96
	Kettle Springs	9/2/08	
	RM 15	4/6/09	
	RM 0	4/17/09	
985121003668558	Kettle Springs	10/22/08	123
	Kettle Springs	2/10/09	
	Parks RM 0 Down	3/18/09	
985121003639824	Kettle Springs	8/6/08	110
	Kettle Springs	8/31/08	
985121003669942	Kettle Springs	9/3/08	112
	Kettle Springs	12/19/08	
985121003670346	Kettle Springs	8/6/08	95
	Kettle Springs	9/3/08	
985121003671065	Kettle Springs	10/22/08	124
	Kettle Springs	12/17/08	

Appendix 20: Fork length, location, and date of tagging and recapture at RM 0

Tagging Location	Tagging Date	FL (mm) at Tagging	Recapture FL(mm)	Recapture Date	FL Growth (mm)	Days of Growth
RM 32	4/17/08	56	144	4/18/09	88	366
RM 32	4/29/08	62	182	4/15/09	120	351
RM 32	4/29/08	62	158	4/16/09	96	352
RM 32	5/8/08	56	151	4/14/09	95	341
RM 32	5/13/08	59	124	4/25/09	65	347
RM 32	5/16/08	56	143	4/16/09	87	335
RM 32	5/16/08	57	133	4/20/09	76	339
RM 32	5/16/08	63	134	4/14/09	71	333
RM 32	5/17/08	57	130	4/20/09	73	338
RM 32	5/17/08	58	146	4/18/09	88	336
RM 32	5/17/08	59	152	4/11/09	93	329
RM 32	5/17/08	60	133	4/11/09	73	329
RM 32	5/17/08	81	169	4/11/09	88	329
RM 32	5/18/08	66	150	4/21/09	84	338
RM 32	5/18/08	67	141	4/13/09	74	330
RM 32	5/18/08	70	150	4/11/09	80	328
RM 32	5/19/08	57	139	4/14/09	82	330
RM 32	5/19/08	59	176	4/16/09	117	332
RM 32	5/19/08	75	140	4/11/09	65	327
RM 32	5/20/08	58	135	5/2/09	77	347
RM 32	5/20/08	58	131	4/13/09	73	328
RM 32	5/20/08	60	151	4/16/09	91	331
RM 32	5/20/08	65	145	3/25/09	80	309
RM 32	5/21/08	57	145	4/20/09	88	334
RM 32	5/22/08	64	160	4/25/09	96	338
RM 32	5/23/08	56	152	4/20/09	96	332
RM 32	6/4/08	85	147	4/20/09	62	320
RM 32	6/6/08	63	140	4/23/09	77	321
RM 32	6/6/08	72	143	4/11/09	71	309
RM 32	10/24/08	109	138	4/15/09	29	173
RM 32	4/7/09	140	146	4/25/09	6	18
RM 32	5/6/09	118	119	5/15/09	1	9
RM 35.2	12/2/08	98	135	4/20/09	37	139
RM 35.2	12/2/08	105	134	4/22/09	29	141
RM 36	6/3/08	69	143	4/29/09	74	330
RM 36	6/4/08	74	128	5/7/09	54	337
RM 36	6/4/08	92	168	4/16/09	76	316
RM 36	11/12/08	99	151	4/14/09	52	153
RM 36	11/12/08	102	157	4/18/09	55	157
RM 36	11/12/08	108	159	4/21/09	51	160
RM 36	12/10/08	100	150	4/21/09	50	132
RM 36	12/10/08	102	138	3/25/09	36	105
RM 36	12/10/08	109	125	4/20/09	16	131

Appendix 20 (cont.): Fork length, location, and date of tagging and recapture at RM 0

Tagging Location	Tagging Date	FL (mm) at Tagging	Recapture FL(mm)	Recapture Date	FL Growth (mm)	Days of Growth
RM 36	12/10/08	110	145	4/11/09	35	122
RM 36	12/10/08	110	154	5/7/09	44	148
RM 36	12/10/08	112	154	4/27/09	42	138
RM 36.8	6/18/08	73	128	4/27/09	55	313
RM 36.8	6/18/08	75	138	4/14/09	63	300
RM 36.8	6/25/08	112	144	5/7/09	32	316
RM 36.8	9/3/08	87	120	4/29/09	33	238
RM 36.8	9/3/08	88	123	4/25/09	35	234
RM 36.8	9/9/08	83	111	4/25/09	28	228
RM 36.8	9/9/08	85	125	4/28/09	40	231
RM 36.8	9/9/08	88	119	4/25/09	31	228
RM 36.8	9/9/08	90	126	4/28/09	36	231
RM 36.8	10/1/08	89	129	4/28/09	40	209
RM 36.8	10/1/08	95	151	4/27/09	56	208
RM 36.8	12/10/08	105	126	5/2/09	21	143
RM 36.8	12/10/08	109	129	4/25/09	20	136
Big Springs Creek Outfall	9/8/08	113	164	4/20/09	51	224
Big Springs Creek Outfall	11/13/08	108	140	4/11/09	32	149
Big Springs Creek Outfall	11/13/08	115	135	4/20/09	20	158
Big Springs Creek Outfall	11/13/08	117	148	4/15/09	31	153
Big Springs Creek Outfall	11/13/08	119	150	4/15/09	31	153
Big Springs Creek Outfall	11/13/08	120	149	4/20/09	29	158
Big Springs Creek Outfall	11/13/08	129	151	4/17/09	22	155
Big Springs Creek RM 1.5	12/5/08	108	138	4/21/09	30	137
Big Springs Creek RM 1.5	12/5/08	114	142	4/21/09	28	137
Big Springs Creek RM 1.5	12/5/08	119	138	4/15/09	19	131
Big Springs Creek RM 1.5	12/5/08	126	156	4/21/09	30	137
Kettle Springs Creek Outfall	8/6/08	96	131	4/18/09	35	255
Kettle Springs Creek Outfall	8/26/08	101	167	4/13/09	66	230

Appendix 21. List of Julian weeks and calendar equivalents

Julian Week #	Inclusive Dates
1	1/1 - 1/7
2	1/8 - 1/14
3	1/15 - 1/21
4	1/22 - 1/28
5	1/29 - 2/4
6	2/5 - 2/11
7	2/12 - 2/18
8	2/19 - 2/25
9	2/26 - 3/4*
10	3/5 - 3/11
11	3/12 - 3/18
12	3/19 - 3/25
13	3/26 - 4/1
14	4/2 - 4/8
15	4/9 - 4/15
16	4/16 - 4/22
17	4/23 - 4/29
18	4/30 - 5/6
19	5/7 - 5/13
20	5/14 - 5/20
21	5/21 - 5/27
22	5/28 - 6/3
23	6/4 - 6/10
24	6/11 - 6/17
25	6/18 - 6/24
26	6/25 - 7/1

Julian Week #	Inclusive Dates
27	7/2 - 7/8
28	7/9 - 7/15
29	7/16 - 7/22
30	7/23 - 7/29
31	7/30 - 8/5
32	8/6 - 8/12
33	8/13 - 8/19
34	8/20 - 8/26
35	8/27 - 9/2
36	9/3 - 9/9
37	9/10 - 9/16
38	9/17 - 9/23
39	9/24 - 9/30
40	10/1 - 10/7
41	10/8 - 10/14
42	10/15 - 10/21
43	10/22 - 10/28
44	10/29 - 11/4
45	11/5 - 11/11
46	11/12 - 11/18
47	11/19 - 11/25
48	11/26 - 12/02
49	12/03 - 12/09
50	12/10 - 12/16
51	12/17 - 12/23
52	12/24 - 12/31**