Affects of Kokanee redd superimposition on bull trout egg-to-fry survival: Summary of initial findings

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This study addresses concerns that kokanee redds superimposed on bull trout redds will reduce the number of bull trout progeny. After bull trout were listed as threatened, a recovery unit team was established to identify the status of bull trout in Odell Lake and determine objectives and goals for recovery. Many research needs were identified; including the impact of kokanee redd superimposition on bull trout emergence success. Trapper Creek, a tributary of Odell Lake, is now the only spawning habitat utilized by bull trout throughout the recovery unit. Historically, it is thought that spawning was more widespread throughout the system (Higgins et al. 2004). Due to an impassable barrier limiting access to upstream habitat, bull trout only spawn in the lower 1.3 kilometers of this creek (Higgins et al. 2005). Kokanee also utilize this portion of the creek extensively. Both species spawn in early fall, with the majority of spawning by bull trout occurring before kokanee arrive. Due to the limited spawning habitat, kokanee superimpose their redds on many of the bull trout redds. This superimposition may have a negative effect on embryo development and fry survival of bull trout.

To evaluate the potential impacts of redd superimposition by kokanee on bull trout egg survival and fry emergence rates, our objectives were to identify the redd structure of undisturbed and superimposed bull trout redds, evaluate the scouring capabilities of kokanee during spawning, and determine emergence rates and timing in superimposed and undisturbed bull trout redds. Because Trapper Creek bull trout population and redd counts are considered precariously low, we elected to conduct this study on the much larger bull trout populations of the upper Metolius River. Heising Spring, a large spring influenced outlet to the Metolius River contains the highest abundance of bull trout redds that become superimposed by spawning kokanee. Following is a summary of results for FY06.

Bull trout egg burial depth sampling

During the fall 2005 and 2006 spawning seasons 26 bull trout redds were assessed to determine the egg burial ability of bull trout in the Metolius River Basin. In 2005, 46 bull trout redds were marked throughout the Metolius basin and their locations saved with a GPS. Sixteen of those redds were then evaluated. Redds were assessed in Candle, Canyon, Jefferson, and Roaring Creeks. Other locations where bull trout redds occurred were not included due to possible disturbance by kokanee. Redds were located by surveying sections of stream where high bull trout redd densities were known to occur.

In 2006, 49 redds were observed and marked in Heising Spring. Ten of those redds were randomly selected to be evaluated. The following are the results of the 2006 sampling. The same excavation techniques as those described in 2005 were used. Egg pockets were identified in all 10 redds evaluated (Table 1). A total of 52 digs were completed. Egg pockets were encountered in 21 of those digs. The number of digs made per redd ranged from 4 to 6. The number of egg pockets encountered ranged from 1 to 4. The average egg burial depth per redd ranged from 10.3 to 19 cm. The combined average egg burial depth was approximately 15 cm.

Table 1. Bull trout egg burial depths in Heising Spring, 2006 (T.O.P. = top of pocket).

Date	Redd #	# of digs	# of egg pockets	Burial depths (cm) to T.O.P.	Average burial depth
9/6/06	**1**	6	4	12,14,15,11	13.0
9/6/06	**2**	6	1	19	19.0
9/20/06	**3**	5	2	11,20	15.5
9/20/06	**4**	6	1	17	17.0
9/20/06	**5**	5	3	10,11,16	12.3
9/27/06	**6**	5	2	18,22	20.0
9/27/06	**7**	4	2	10,20	15.0
10/4/06	**8**	4	1	14	14.0
10/4/06	**9**	5	2	13,19	16.0
10/4/06	**10**	6	3	8,15,8	10.3
Total		52	21		15.0[a]

a. Average.

Kokanee egg burial depth

The egg burial ability of kokanee was also evaluated using the same excavation techniques as those described in 2005 for bull trout egg burial depth sampling. However, due to the manner in which kokanee spawn (i.e. in large aggregates, superimposing each other's redds) exact redd peripheries and redd characteristics were often undistinguishable from the surrounding substrate. Therefore, redds could not be easily identified in advance and excavation completed at a later date. Instead, kokanee scouring areas were evaluated in both Trapper Creek and Heising Spring. Kokanee scouring areas were arbitrarily located and observed for an unidentified amount of time. Locations were females dug; the number of kokanee in the area, the relative size of the area (m^2), and any distinct mounds were noted. The diver then entered the water upstream of the area and began excavation on any location thought to contain egg pockets. A second person (recorder) directed the diver and recorded all depth measurements relayed to them. After a dig was completed and the diver had moved on, the recorder measured the water velocity directly in front of the dig site.

In Heising Spring, only 4 egg pockets were identified out of the 11 scour areas excavated (Table 2). A total of 14 digs were attempted, ranging from 1 to 2 digs per scour area. Although only 4 egg pockets were identified, eggs were observed during most all digs. Egg pocket depths ranged from 5 to 10 cm and averaged 8 cm. Digs completed during the 2005 field season are not included because no egg pockets were ever found.

Table 2. Kokanee egg burial depths in Heising Spring, 2006.

Date	Scour Number	Number of digs	Number of egg pockets	Burial depths to T.O.P (cm)
9/27/06	1	2	0	
10/13/06	2	1	0	
10/13/06	3	1	1	10
10/13/06	4	1	0	
10/13/06	5	2	0	
10/13/06	6	1	0	
10/13/06	7	1	1	8
10/13/06	8	1	0	
10/13/06	9	2	1	8
10/13/06	10	1	1	5
10/13/06	11	1	0	
Total		14	4	8[a]

a.. Average

In Trapper Creek, 17 egg pockets were identified during 37 digs made in 30 different kokanee scoured areas (Table 3). A range of 1 to 4 digs was made per scoured area. Egg pocket depths ranged from 1 to 10 cm and averaged 5 cm.

Table 3. Kokanee egg burial depths in Trapper Creek, 2005–2006.

Date	Scour Number	Number of digs	Number of egg pockets	Burial depths to T.O.P (cm)
9/27/2005	**1**	2	2	1, 3
10/4/2005	**2**	4	0	
10/4/2005	**3**	1	0	
10/4/2005	**4**	1	1	3
10/4/2005	**5**	1	0	
10/4/2005	**6**	1	1	4
10/4/2005	**7**	1	1	4
10/3/2006	**8**	3	0	
10/3/2006	**9**	2	0	
10/3/2006	**10**	1	0	
10/11/2006	**11**	1	1	6
10/11/2006	**12**	1	0	
10/11/2006	**13**	1	0	
10/11/2006	**14**	1	0	
10/11/2006	**15**	1	1	8
10/11/2006	**16**	1	1	6
10/11/2006	**17**	1	1	4
10/11/2006	**18**	1	0	
10/11/2006	**19**	1	1	3
10/11/2006	**20**	1	1	4
10/11/2006	**21**	1	1	7
10/11/2006	**22**	1	1	7
10/11/2006	**23**	1	0	
10/26/2006	**24**	1	1	6
10/26/2006	**25**	1	1	7
10/26/2006	**26**	1	0	
10/26/2006	**27**	1	1	9
10/26/2006	**28**	1	1	10
10/26/2006	**29**	1	0	
10/26/2006	**30**	1	0	
Total		37	17	5[a]

a.. Average

Emergent Fry Trapping

Fourteen emergent fry traps were placed on bull trout redds in Heising Spring during January 2006. Two additional traps were installed on bull trout redds in Roaring Spring in February 2006. All trapped redds were chosen based on estimated emergence timing, presence or absence of kokanee superimposition, and ability to locate original redd periphery. Seven of the fourteen traps in Heising Spring were placed on redds considered to be superimposed by Kokanee, all other trapped redds were considered undisturbed.

Fry emergence traps were set on redds in Heising Spring 125–144 days after redd formation. Roaring Spring traps were set 176 days after redd formation. Trap placement timing was dependent on accumulative Celsius temperature units (CTU's). Onset temperature data loggers were placed throughout the Metolius basin in early August 2005 and set to record hourly stream temperatures (± 0.01 ºC). The average daily temperature was determined and accumulated over time from the date a redd was first observed. All traps were installed between 700 and 808 CTU's. Setting the traps within this range minimized negative impacts associated with trap installation and insured that traps were functioning before fry emerged. Fry emergence was predicted to begin around 820 CTU, based on previous work. Traps were checked and cleaned daily to every other day until emergence began to slow, at which point they were checked and cleaned once to twice a week. Captured fry were emptied into an 18.9 liter bucket filled with fresh stream water for identification and enumeration. During peak emergence some traps were emptied more than once per visit to reduce stress caused by live well crowding. All whole captured fry and alevin were identified to species and recorded as either live or dead. Fry fragments were not counted, but noted. After enumeration all captured fry were released into the stream margin. Over the course of the trapping period a small sub-sample of fry (n =101) from one of the Roaring Spring traps were retained and measured for total length (± 1 mm) using a measuring board. Fry trapping was discontinued on one of the Roaring Spring traps on March 22, 2006 due to consistently high trap induced mortality. All other trapping was terminated by June 13th, 2006.

A combined total of 27,065 bull trout and kokanee fry were captured during the 2006 emergence period. Bull trout fry were captured in all trapped redds. A total of 17,340 bull trout were captured out of the 14 redds trapped in Heising Spring. In the two Roaring Spring traps a total of 9,015 bull trout were captured. The average total length of those fry was found to be 27.5 mm. A total of 710 kokanee were captured in Heising Spring. Kokanee were captured in 4 of the 7 superimposed redds there. Although more bull trout fry were captured out of superimposed redds in Heising Spring, there were no significant differences between the two redd populations (Table 4). On average more fry were captured out of the superimposed redds, but there was a substantial range of the number of fry captured across all redds (31–2601 fry).

Table 4. Bull trout fry emergence data in Heising Spring, 2006.

Redd	Redd Type	Live	Dead	Total
1	Undisturbed	1,876	116	1,992
2	Undisturbed	1,587	23	1,610
3	Undisturbed	1,272	237	1,509
4	Undisturbed	767	12	779
5	Undisturbed	726	37	763
6	Undisturbed	618	3	621
7	Undisturbed	31	0	31
8	Superimposed	2,584	17	2,601
9	Superimposed	2,095	14	2,109
10	Superimposed	1,622	64	1,686
11	Superimposed	1,350	14	1,364
12	Superimposed	1,222	4	1,226
13	Superimposed	529	4	533

14	Superimposed	508	8	516

Redd Substrate Core Sampling

Two substrate core samples were removed from each trapped redd in Heising and Roaring Springs during June and July 2006 (n = 30). No samples were removed from the Roaring Spring redd that ended trapping early due to high mortality. To minimize any between redd variability; all samples were taken immediately after each trap was removed. During September and October 2006 an additional 5 substrate core samples were removed from 5 separate Trapper Creek bull trout redds marked during the 2005 spawning season. Only one sample was taken per redd in Trapper Creek due to difficulty identifying exact redd margins.

A 25 cm diameter modified McNeil sampler was used to collect the redd substrates to a depth of 20 cm. Collecting redd substrates to a depth of 20 cm was thought sufficient to characterize the egg pocket environment. Each redd was sampled along the midline. The first sample was collected at the transitional zone between the redd pot and tailspill. For those redds sampled twice, the second sample was collected approximately 15 cm downstream of the first near the tailspill crest. After the sampler was in place the core substrate was excavated by hand to the desired depth and transferred into an 18.9 L bucket. Excavation ceased when the bottom circumference of the sampler could be felt in its entirety. To account for the remaining suspended sediment within the core a 1000 ml container was immersed in the core water column and allowed to fill. Before immersing the container, the core water was stirred by hand for 3–5 seconds. The distance from the top edge of the sampler to the water surface in the core was also recorded so that core water volume could later be calculated.

Removed substrates were separated into geometrically decreasing substrate size classes of ≥ 64, 32, 16, 8, 4, 2, 1, 0.5, 0.25, 0.125, 0.0625 mm, and pan (< 0.0625 mm). Weight (g) and volume displacement (ml) was determined for each particle size class. Total suspended sediment weight and volume was estimated for each core sample based upon the original volume of water in the core. The estimated values were added to the weight and volume of the pan.

Sediment particle size distribution and gravel indices (e.g. cumulative percentage of fine sediment < 2.0 mm and geometric mean particle diameter (Dg) in mm) for each whole sample were calculated using custom software GRAVEL©. GRAVEL© was also used to characterize the entire redd by pooling samples if more than one sample per redd had been collected. Multiple linear regression will be used in combination with Akaike's Information Criterion (AIC-adjusted for small sample sizes) to evaluate relationships between the number of fry that emerged from a given redd and various redd variables. The dependent variable will be the log (x+1) transformation of the number of emergent bull trout fry captured per fry emergence trap. The transformation is necessary to approximate normality. Approximate redd area, average water velocity over the redd, percentage of fine sediment < 2.0 mm in diameter, Dg, and superimposition will be used as independent variables. The independent variable, "superimposition" will be treated as a dummy variable and coded 0 for undisturbed redds and 1 for redds superimposed by kokanee.

Kokanee Scour Monitoring

Sliding-bead monitors were used to determine the collective scouring and depositional capabilities of a large spawning aggregate of kokanee. Similar to scour chains, which measure scour and fill of sediments over a period of time, sliding-bead monitors work in much the same manner. The devices, composed of a steel-drop point and a length of braided steel wire with beads threaded on, are driven vertically into the streambed to a desired depth. As a scouring event occurs beads are released from the stream bottom into the water column and swept to the end of the cable. The length of beads released represents the depth of the scouring event. In much the same way, if any sediment is deposited on top of the device, the amount of fill can be determined by measuring the length of cable covered from the top of the last sedentary bead to the streambed surface.

Before kokanee arrived, 30 sliding-bead monitors were installed in Trapper Creek during August 2006. The monitors were set in 8 transects with 2–6 monitors per transect, in pool tailouts known to support high numbers of spawning kokanee. The number of monitors per transect was dependent on the width of the pool tailout and the available spawning substrate. On November 20, 2006, after all kokanee had finished spawning, 29 of the original 30 monitors were relocated and assessed to determine the amount of scour and deposition that had taken place. One monitor in transect eight could not be found. Scour depth was determined by multiply the number of exposed beads per monitor by 1.2 cm (i.e. the height of single bead). Depositional depth was determined by first measuring the depth from the waters surface to the streambed directly above each monitor. The substrate over the monitor was then removed until the top bead was exposed and a second depth measurement was recorded. Deposition was calculated by subtracting the second depth measurement from the first.

Active kokanee digging was observed on or directly near all monitors. The dominant substrate found around the monitors was small pebbles (b-axis ranged 16–31mm). The average water velocity increased some what from when monitors were first installed to when they were reevaluated, but is not thought to have influenced scour and deposition. Some degree of scour occurred on 24 of the 29 monitors evaluated and some degree of deposition occurred on all but 1 monitor (Table 5). The overall average depth of scour was 4.0 cm and ranged from 1.2 (1 bead) to 8.4 (7 beads) cm. The overall average depth of deposition was 4.7 cm and ranged from 1 to 15.5 cm.