ADULT AND JUVENILE STEELHEAD POPULATION SURVEYS, GUALALA RIVER, CALIFORNIA, 2008

Richard W. DeHaven[1]
Fish and Wildlife Biologist
December 31, 2008

Wheatfield Fork, Gualala River, just upstream of the Annapolis Road (Clark's Crossing) bridge. This site is a summer snorkeling location and the lower boundary of the upstream half of the Index Reach. Dewatering in this area during summer 2008 was the most severe in 8 years of intensive study and 37 years the author has been observing the stream. A few days after the photo was taken, the site was completely dry.

---

[1]Senior Fish and Wildlife Biologist (Retired 2004); U.S. Fish and Wildlife Service, Sacramento, California.
Recommended Report Citation: DeHaven, R. W. 2008. Adult and juvenile steelhead population surveys, Gualala River, California, 2008. Prepared by the author (drdehave@hotmail.com), December 31, 2008, for use by agencies, groups and individuals involved in steelhead recovery efforts. 67 pp. (This report, with Appendix, to be available on the author's website at http://www.gualalariversteelhead.info/ by mid-2009.)

SUMMARY: *Seasonal spawning surveys of adult steelhead conducted in 2002-2007 along an 18.7-mile reach (Index Reach) of the Wheatfield Fork, Gualala River, California, were continued in 2008. The Index Reach was surveyed six times (112 miles) from a small, aluminum drift-boat between late December 2007 and mid-April 2008. The highest seasonal total count of fish to date–1,402–was recorded, with numbers peaking in late January and March; the average of 234 adult fish per survey compared to a range of 15 (2004) to 84 (2007) over the six preceding seasons. A provisional (pending further refinements) spawning population estimate for the Wheatfield Fork, based on area-under-the-curve-trapezoidal (AUC-T) methodology, was 4,300-5,800 fish, or about two to twelve times higher than the six earlier (high-low) seasonal estimates. The population uptick in 2008 likely resulted from good rearing conditions (lower water temperatures, higher stream flows, and lack of summertime dewatering) and production for juvenile steelhead (JSH) in summer, 2005 and 2006, due to abundant springtime rainfall both years. A total of 47 steelhead redds was also recorded, although as in past years, most spawning occurred upstream of the Index Reach. Axillary spawning surveys in 2008 along the lower half of the Index Reach, done to improve estimates of Survey Life (SL) integral to the AUC-T methodology, provided a new SL function to account for how fish movements slow and "stacking" then occurs at "favored" holding sites, as stream flow lowers from 150 to 75 cfs. Summertime snorkeling surveys of JSH were also continued in 2008 at 15 established 100-ft-long sites. Snorkeling results in June revealed high densities of JSH (366/site=3.7/ft), a clear reflection of a large 2008 spawning run. However, owing to record springtime drought in the watershed, with only 1 inch (12% of average) of rainfall during March-May, poor conditions for JSH rearing and production subsequently ensued. By late August 2008, JSH densities had declined dramatically to levels (57/site=0.6/ft) similar to previous seasons, a likely result of widespread dewatering, related elevated water temperatures, and lack of stream connectivity needed for JSH to escape lethal conditions and move to cool-water refugia. Summertime dewatering in 2008 was the most severe the author has observed on the stream in 4 decades and this worsening phenomenon poses a serious impediment to salmonid restoration.*

INTRODUCTION AND BACKGROUND

Due to a lack of current information on the population status of steelhead in the Gualala River, a mid-sized northern California coastal stream, I initiated annual spawning surveys of steelhead on the river in 2001 (DeHaven 2001). These surveys were continued and expanded in 2002 through 2007, focusing on an 18.7-mile reach of the Wheatfield Fork used as an Index Reach for long-term population-indexing (DeHaven 2002-2007). In this report, I present results of 2008 spawning surveys along the Index Reach.

In addition, during summer 2004, I conducted reconnaissance-level snorkeling surveys of juvenile steelhead (JSH) at strategic locations throughout the watershed. From the initial snorkeling results, a long-term snorkeling-survey protocol, to complement the spawning surveys, was developed and implemented in 2005. The 2008 results of the snorkeling protocol are also presented here.

Results from spawning and snorkeling surveys will be coalesced over at least a 10-year period in an effort to describe the current status and trend of the river's steelhead population. Related objectives of my work include furthering knowledge of life history of the river's steelhead; identifying the most serious threats to the river's steelhead and coho salmon; and helping to develop the most effective strategies to aid recovery of these listed species. The flow of information towards these objectives occurs through reports, such as this one, and via my website (http://www.gualalariversteelhead.info/). In addition, in 2008, I began a series of public seminars and lectures to begin to disseminate findings, conclusions and recommendations.

This 2008 report does not restate the study methods. Refer to the previous annual reports, especially the 2007 report, for descriptions of procedures.

As in previous years, for each individual survey (i.e., spawning or snorkeling survey) a Memorandum to the File (File Memo=FM) was prepared. FMs are diary-type field reports; most have undergone minimal editing. FMs may include procedures, raw data, findings, discussions, conclusions and photographs–sometimes in greater detail than presented in annual reports such as this one. For 2008, a total of ten FMs (82-91; Appendix1) was prepared. The FMs and this annual report will be available on my website early in 2009.

I thank four friends for their assistance during 2008 field work. Marc Felton and Greg Benke, helped on some of the spawning surveys; and Tom Cannon and E. B. assisted on some of the snorkeling surveys.

RESULTS AND DISCUSSION

Spawning Surveys

Number and Timing of Surveys–Six complete surveys of the Index Reach were conducted between December 25, 2007 and April 13, 2008 (Table 1; FMs 82-86, 88). One survey each occurred in December, January, February and April, while two were conducted in March. This distribution of surveys was basically a function of stream flow; I attempted to survey roughly every 2 weeks, but rainfall, flows and water clarity governed when surveys were practicable.

In addition, on March 30-31, 2008 a survey and resurvey (following day) of the lower half (9.4 miles) of the Index Reach was conducted. The purpose was to gather data for refining the AUC-T (area-under-the-curve, trapezoidal) population estimation procedure (*see* Methods, 2007 Annual Report), specifically the SL (Survey Life) parameter. March 30-31 survey results were not included in totals across the bottom of Table 1, nor were they directly used in deriving the AUC-T population estimate for 2008. Results were instead used to refine and improve the SL estimation procedure used in the AUC-T methodology.

Number of Redds–A total of 47 steelhead redds was found, including 22 and 25 along the upper and lower halves, respectively, of the Index Reach (Table 1; FMs 82-86, 88). The first redd was not found until March 6 and the majority (38=81%) were found during the final survey on April

Table 1. Steelhead spawning survey results, Wheatfield Fork Index Reach, Gualala River, 2008 season.[1]

Date(s) and Observer(s)	Conditions			Number Adults							% Kelts	Number Redds		
						By Size Class								
	F	C	W	Up. Rch.	Lwr. Rch.	1	2	3	4	T		Up. Rch.	Lwr. Rch.	T
12/25-26; RD	M	F	F	49	70	0	69	50	0	119	2	0	0	0
1/20-21; RD/GB	M	F	F	141	106	31	115	101	0	247	7	0	0	0
2/16-17; RD/GB	H	F	E	64	128	4	99	89	0	192	6	0	0	0
3/6-7; RD	H	F	E	91	185	11	156	109	0	276	26	1	0	1
3/23-24; RD	M	E	E	167	307	38	284	152	0	474	8	4	4	8
3/30-31; RD	--	--	--	--	491	n/a	n/a	n/a	n/a	491	n/a	--	--	--
4/12-13; RD/MF	L	E	E	69	25	1	57	36	0	94	62	17	21	38
Totals	-	-	-	581	821	85	780	537	0	1402	19	22	25	47

[1]*See individual survey reports (File Memos #82-86, 88) for further detail. Conditions as follows:* ***flow (F)***: ***H****igh=>200 cfs;* ***M****oderate=75-200 cfs;* ***L****ow=<75 cfs.* ***clarity (C)***: ***E****xcellent=bottom of all pools visible;* ***F****air=bottom of up to one-half of the deepest pools not visible.* ***weather (W)***: ***E****xcellent=sunny and clear, with little or no wind during most of day;* ***F****air=clouds, rain, fog, wind, or other adverse weather factors hampered visibility of the bottoms of the deepest pools during half of more of the survey. Adult size criteria: size 1=≤24 inches TL (roughly 2-4 lbs); size 2=25-31 inches TL (roughly 5-10 lbs); size 3=≥32 inches TL (roughly ≥10 lbs); and special note made of any very large adults over ≥34 inches TL (size 4=roughly ≥15 lbs).*

NS=Not Surveyed The March 30-31 (File Memo #087) survey was a first-ever back-to-back survey of the lower Index Reach only, and its totals are not included in seasonal totals across the bottom of the table, nor was this survey used in estimating the population using AUC-T methodology.

12-13. This pattern was consistent with previous years in which most early-season spawning, and/or spawning during periods of higher flows, occurred upstream of the Index Reach.

As in previous years, redds were widely distributed throughout the Index Reach. However, one redd about 1/4-mile upstream of the Wheatfield Fork bridge (lower Index Reach downstream boundary) established a new record for the lowermost spawning site found to date. The 47 total redds was similar to the 38 found in 2007, but substantially more than the 2 found in 2006.

During the 2-day (March 30-31) survey-resurvey of the lower half of the Index Reach, ten new redds were discovered, one of which was apparently missed on the first day. This demonstrated how even a very experienced observer can have observer error in redd detection. Locations (GPS coordinates) for 2008 redds are given in FM 88. Eventually, all redd locations (i.e., maps and tabular data) found during annual surveys will be available on my website.

Although I did not identify and track "new" individual lamprey redds throughout the season (i.e., only a total count was made for each survey) to derive a seasonal lamprey redd total, lamprey redds were clearly in relatively low numbers, just as observed in 2007. The first lamprey redd of the season was found on January 21, but no additional redds were found until March 24, when 15 were recorded–all along the upper survey reach. Four lamprey redds were then recorded on March 30. The final survey on April 12-13 yielded 25 lamprey redds, 2 live lampreys (spawning), and 1 lamprey carcass (with head missing). In comparison, for 2007, a maximum of 35 lamprey redds was recorded (March 29-30) and over the entire season, only three live lamprey were observed.

Numbers of Live Adult Steelhead and Steelhead Carcasses–Fish numbers were tracked separately for the six complete surveys of the Index Reach versus the March 30-31 survey-resurvey of the lower half of the Index Reach.

Six Complete Index-Reach Surveys. Two carcasses of adult steelhead were found, one on March 6 (FM 85) and one on March 23 (FM 86).

A total of 1,402 adult steelhead was tallied during the six complete surveys, including 581 (41%) and 821 (59%), respectively, on upper and lower survey reaches (Table 1; FMs 82-86, 88). This was by far the most fish counted to date on the Index Reach in a single spawning season and was nearly twice the previous high count of 762 fish recorded during nine complete surveys in 2007.

The six 2008 surveys yielded unadjusted counts (i.e., no correction for observer error=OE) of from 94 to 474 fish. The two highest counts–474 and 276 fish–were in late and early March, respectively; the third highest count of 247 fish was in late January. The first survey in late December yielded 119 fish, an unusually high number for so early in the season. The lowest count of 94 fish–a relatively high value for so late in the season–was on the final survey in mid April. Such consistently high counts throughout the spawning season were one indicator of a large overall spawning return.

Another indicator of a significant population uptick in 2008 was the record-setting sizes of groups of fish. In particular, during previous seasons, a count of 25 fish in a single group was a relatively high number and the previous record high group count was 45 adult fish recorded in one pool in 2007. In contrast, in 2008, during the four surveys conducted between late January and late March, 15 groups of fish had ≥25 fish (FMs 82-86, 88), with eight of these having ≥40 fish and four having ≥50 fish. Also, a new record high group count of 75 fish occurred on the March 22-23 survey-resurvey (FM 86). Several underwater photographs of large groups of adult fish recorded in 2008 appear in FM 86.

Estimated adult numbers by size class were: 85 (6%-*vs 25% in 2007*) size #1, 780 (56%-*vs 53% in 2007*) size #2, and 537 (38%-*vs 22% in 2007*) size #3 (Table 1; #1=≤24 inches TL, #2=25-31 inches TL, and #3=≥32 inches TL). Thus, compared to 2007, 2008 trended towards more larger (presumably older or healthier) fish. Size estimates given here are tenuous, however, because of lack of validation. No very large adults (size #4; ≥34 inches TL) were recorded in 2008.

Steelhead kelts were recorded during each of the six 2008 surveys, including the first survey in late December (Table 1). Kelts averaged 19% of adult fish recorded per survey and were, as expected, in highest abundance–62%–during the final, mid-April survey. The second-highest kelt percentage of 26% occurred during the mid-February survey. However, as I have discussed previously (*see* Gualalariversteelhead website), because of the difficulty in determining status of adults (i.e., kelts vs pre-spawners), which are only briefly observed from a boat and are thus not being handled, kelt numbers and percentages are, at best, tenuous.

March 30-31 Survey/Resurvey--Lower Reach. The purpose was to determine whether adult steelhead were still freely moving up-and-downstream, or whether movements had ceased or slowed in response to rapidly falling, unusually low, stream flow. In pursuit of this objective, I counted the adults present in key "favored" resting and holding areas on day one and compared results to counts at the same places on the following day. The assumption was that either a large overall day-to-day change or large changes in numbers at individual sites would indicate that fish were still moving; if counts were similar overall between days and/or at individual sites, the inference would be that fish were stacking and holding instead of moving. The large spawning return of adults in 2008 afforded a perfect opportunity for this kind of comparison, because relatively large numbers of adult fish were likely to be observed and counted.

The flow thresholds (upper and lower) which curtail fish movements are important to calculation of population estimates with the AUC-T methodology I am employing, specifically the derivation of SL (=number of days fish spend in the survey area) estimates (*see* 2007 Annual Report). Initially, I had assumed that the weekly spawning-season SL (i.e., for the 18.7-mile Index Reach only) was a basic 6 days, plus any additional consecutive days (i.e., starting within 6 days after each weekly SL estimation date) that the stream flow was either continuously high at ≥3,000 cfs or continuously low at ≤50 cfs, with such flows assumed to be"zero movement" thresholds. Thus, 50 cfs was considered to be the low-flow threshold where all adult fish stop moving. However, during the March 23-24, 2008 survey (FM 86) conducted at a flow of about 135-125 cfs (Navarro gage [an index to Wheatfield Fork]), there were already indications (relatively high counts at some favored sites) of stacking being underway. The survey-resurvey on March 30-31 was designed to build on this observation.

The result for the 2-day count was 491 total (unadjusted for OE) adult steelhead, including 235 on March 30 and 256 on March 31 (FM 87). All but four (<1%) of the total fish were in named pools or flatwater areas where fish are regularly tracked; an analysis of nine of these sites ensued to address the survey objective. Results (*see* FM 87) suggest that a relatively small percentage of adult steelhead, perhaps mostly scattered small numbers of kelts, were still actively moving and that most adult fish were stacked and holding in favored sites.

Over the 2 days of the survey, the hydrograph declined from roughly 90-95 cfs to about 80-85 cfs (based on the Navarro and South Fork, Gualala river stream gages). This suggested that the initial 50 cfs zero movement criterion used in SL derivations was too low of a threshold value.

Instead, a more reasonable zero movement low-flow criterion is probably about 75 cfs. Also, a transitional flow dimension, as the flow declines from about 150 cfs, where stacking may begin, down to 75 cfs, where stacking becomes highly pronounced, is suggested. This transitional period can be expressed as a linear function, with zero movement days (i.e., days added to the basic 6-day SL) varying from zero (150 cfs) to 1.0 (75 cfs), depending on flow. The resulting descriptive equation is:

> ***a=(-0.0133)b + 2****, where a=days added to SL for each day of designated stream flow and b=average daily stream flow in cfs for any given date.*

Some representative zero movement values derived with this function are: 135 cfs=0.2 (i.e., 0.2 day added to basic SL); 120 cfs=0.4; 105 cfs=0.6; 90 cfs=0.8; and 75 cfs=1.0.

This transitional-flow function has already been incorporated into the AUC-T procedures, specifically for the derivation of weekly SL estimates over each spawning season. Thus, both the 2008 population estimate(s) reported herein and the 2002-2007 annual population estimates initially given in the 2007 Annual Report (edited April 6, 2008) reflect the appropriate changes.

Precipitation and Hydrology**–**The watershed's total rainfall in 2008 was, for a second consecutive year, below average. Although the 45.5 inches recorded (VEN gage) from 16 rainfall events (Table 2; event=one or more consecutive days of measurable precipitation) was about 4.5 inches more than for 2007, it was about 17% below average and just one-half the 84 inches recorded in 2006.

In addition, the temporal rainfall pattern for 2008 was highly uneven (Figure 1; Table 2). Only October, December and February had rainfall totals close to long-term monthly averages. But January was far wetter (>2x) than average, with about 22 total inches. One unusually large rainfall event started on January 21st and lasted 14 days into early February; during one day (January 25th) of this period, 4.72 inches was recorded. However, the above-average rainfall extending into early February was followed by record-setting drought at the end of the rainfall season. In particular, during March through May, a total of only 1.08 inches–about 12% of average–was recorded.

The seasonal (November 2007-April 2008) hydrograph for the Wheatfield Fork, as inferred from the South Fork, Gualala and Navarro river gages, and based on daily mean discharge, showed five significant flow peaks (Figure 2). The highest and second-highest peaks were about 10,000-12,000 cfs on January 3rd and about 7,000-8,000 cfs on January 21st, respectively. Instantaneous flow peaks (Table 2) for these events reached about 25,000 cfs (January 3rd) and 11,000 cfs (January 21st), respectively. Another significant instantaneous peak of about 9,000 cfs occurred on February 21st. Otherwise, instantaneous flow peaks were all ≤2,000 cfs. Moreover, the three flow peaks during the record dry springtime (March-May) were barely measurable at only about 10-25 cfs each. Thus, in terms of both rainfall and flows, springtime 2008 was truly an historic dry period for the Gualala River watershed.

Table 2. Annual precipitation and rainfall event log for the Gualala River watershed, 2007-2008 season (October-September), as inferred from the realtime rainfall gage located at Venado on the Russian River watershed. (Flow effects as inferred from the realtime stream gage on the Wheatfield Fork, Gualala River until October 23, 2007 when it was discontinued by USGS; thereafter, flows were inferred from the realtime gage on the Navarro River near Navarro.)

No.	Starting Date	No. Consecutive Days Rainfall	Max. 1-Day Rainfall (in)	Total Event Rainfall (in)	Max. Effect on River Flow at Twin Bridges	Season Cum. Total Rainfall (in)
1	Oct 09	4	1.12	2.48	+20 cfs	2.48
2	O ct 15	5	0.56	1.36	No change	3.84
3	Nov 11	2	0.56	0.80	No change	4.64
4	Nov 19	1	0.04	0.04	No change	4.68
5	Dec 02	3	1.68	2.68	+400 cfs	7.36
6	Dec 06	2	0.68	0.80	+500 cfs	8.16
7	Dec 16	5	2.36	5.80	+2,000 cfs	13.96
8	Dec 27	3	0.36	0.48	No change	14.80
9	Jan 03	8	5.84	9.00	25,000 cfs	27.40
10	Jan 12	2	0.04	0.08	No change	27.48
11	Jan 21	14	4.72	12.78	+11,000 cfs	40.20
12	Feb 19	1	0.12	0.12	No change	40.32
13	Feb 21	4	2.16	4.08	+9,000 cfs	44.40
14	Mar 13	3	0.12	0.28	+25 cfs	44.68
15	Mar 28	1	0.24	0.24	+10 cfs	44.92
16	Apr 22	2	0.44	0.56	+20 cfs	45.48

Effects of drought in the watershed were readily observable. For example, by the end of April 2008, the Wheatfield Fork had already declined to just 35-50 cfs and was dropping rapidly (Figure 2). And by the end of summer 2008, dewatering was pervasive. Dewatering in the vicinity of Twin Bridges (Wheatfield and South forks confluence) and upsteam along the Wheatfield Fork was the worst I have observed in the 8 years I have worked intensively on the river and 37 years I have been a casual observer. Several photographs of dewatered snorkeling sites at the end of summer appear in FM 91.

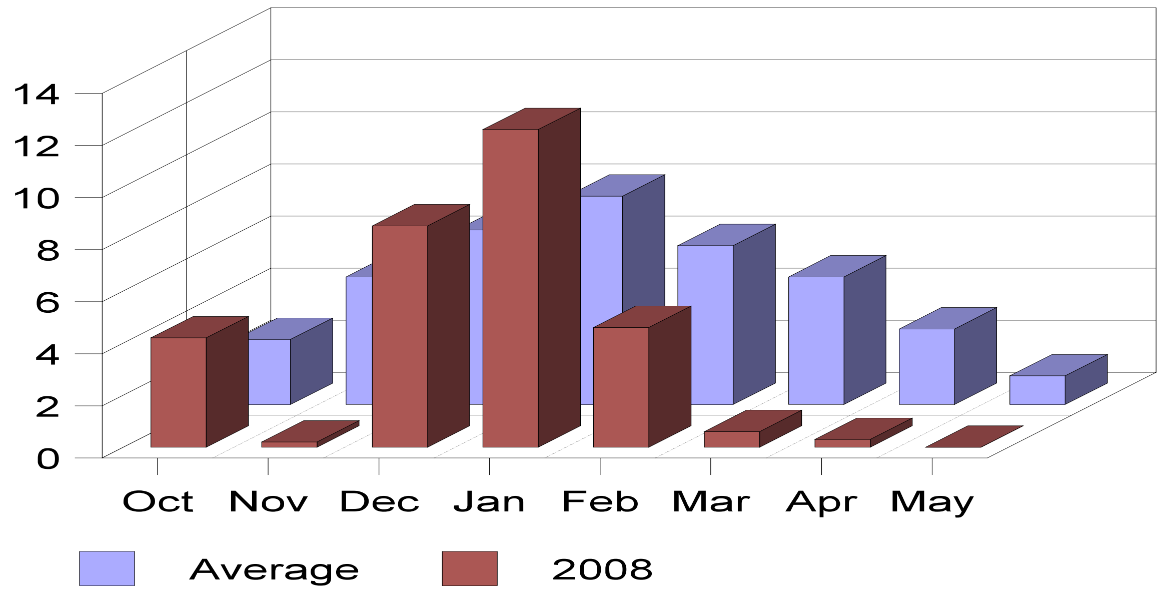

Figure 1. Gualala River monthly rainfall pattern for the 2008 steelhead spawning season, as inferred from the real-time rain gage at Venado (VEN) in the Russian River drainage.

***Population Estimates*–**The estimated 2008 spawning population of steelhead for the Wheatfield Fork, based on AUC-T methodology described in my 2007 Annual Report and six complete surveys of the Index Reach, was 5,843 fish (Table 3; Figure 3). This number is 2.5 times higher than the previous high annual estimate of 2,375 fish in 2005 and 12 times above the lowest annual estimate of 486 fish in 2004. Thus, 2008 was clearly the largest spawning return over the 7-year study period (2002-2008) to date; moreover, due to its basis, I believe that it may have been the largest adult return in decades.

I have already described in detail (*see* gualalariversteelhead website) how a record adult return in 2008 was likely ultimately tied to abundant springtime rainfall in 2005 and 2006. High springtime rainfall those years created unusually good summertime rearing conditions for JSH. Thus, with low over-summer mortality, record numbers of JSH ultimately migrated to sea, providing the basis for a record return of adult fish 2-3 years later (2008).

Nevertheless, because of present inability to actually measure uncertainty of present AUC-T population estimates, how well the 2008 population estimate reflects reality cannot be assessed. The answer depends largely on the accuracy of SL and OE estimates which are fundamental to calculations. For example, with assumption of a SL underestimate (from the estimate used) of 50% (i.e., real SL=2.0 x estimate) the population estimate would be 2,922 (i.e., column ".50E" in Table 3) fish; but such a low value appears unrealistic, given that 1,402 fish were actually counted (i.e., 48% of estimate) during just six surveys over a 5-month spawning season . On the other hand, assuming a SL underestimate of 25% (i.e., real SL=1.5 x estimate) would yield a

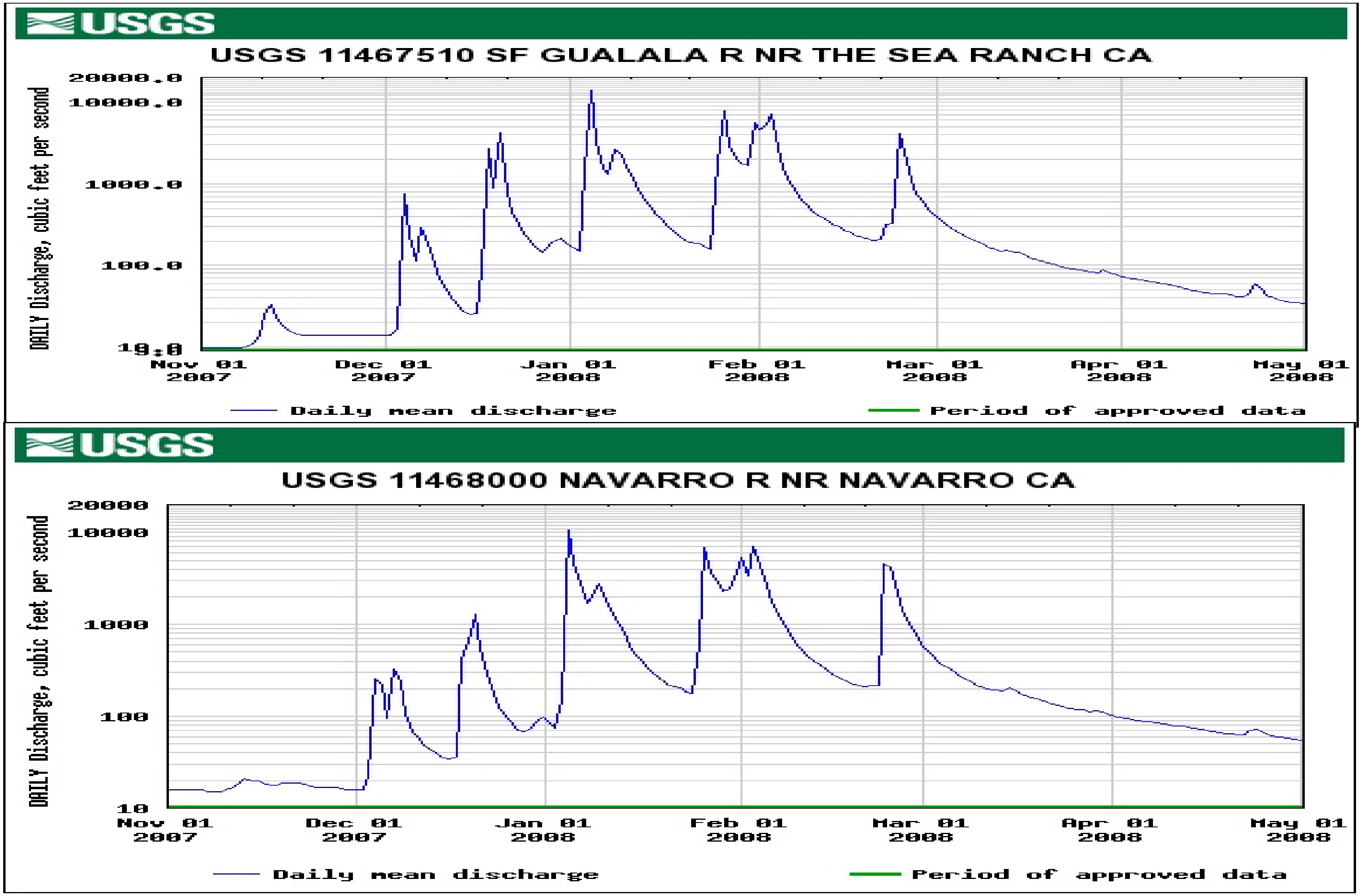

Figure 2. Gualala (South Fork) and Navarro river hydrographs for the 2008 steelhead spawning season, November 2007 to May 2008, from provisional USGS gaging data.

Table 3. Index Reach adult steelhead spawning population parameters, 2002-2008. *(Provisional results subject to revision from further refinement of Observer Error and Survey Life estimates used in AUC-T methodology.*)

Year	N	Total Adult Count	Ave.	Spawning Season[1]		Low[2] or No Move Days	Survey Life [3] (days)	Obs.[4] Eff. (%)	AUC-T Population Estimate(s)[5]		
				Start Date	Lngth Days				Est. (E)	.75E	.50E
2002	8	377	47.1	11/22	159	60	9.7	40-80	1584	1188	792
2003	4	211	52.8	12/14	137	25	7.0	40-50	1543	1157	772
2004	8	121	15.1	12/07	144	27	7.1	20-80	486	365	243
2005	7	433	61.9	12/07	144	19	6.4	20-80	2375	1781	1188
2006	4	86	38.3	12/01	151	31	7.6	20-80	1036	777	518
2007	9	762	84.7	12/12	139	72	10.2	40-80	2086	1565	1043
2008	6	1402	233.7	12/06	147	77	11.5	28-75	5843	4382	2922
Ave.	6.6	484.6	76.2	12/05	145.9	39.0	8.0	20-80	2136	1602	1068

[1]The start of each season's spawning run within the survey area (Index Reach) was assumed to occur on the day when the first seasonal stream flow (Wheatfield Fork gage) was $\geq$500 cfs. End of the spawning season was always assumed to be April 30. [2]In deriving Survey Life (SL), adult steelhead movement rate was assumed to be reduced, thus extending SL, when stream flows were either $\geq$3,000 cfs or $\leq$150 cfs (*see* Methods). [3]Survey Life (SL) is also known as Residence Time. SL is the average time adult steelhead were estimated to spend in the survey area (Index Reach) each season, as determined from weekly estimates derived from seasonal hydrology (*see* text for further detail). [4]Observer Efficiency (OE) is the estimated proportion of the true population counted during surveys. OE was estimated separately for each survey (*see* text), based on stream flow, water clarity, and key weather parameters, all of which affected counts of fish. [5]The 75% and 50% values are not statistically-derived population estimates and are provided only for evaluating reasonableness of the estimates (E).

population estimate of 4,382 (i.e., column ".75E" in Table 3) fish, a number more difficult to reject as unreasonable.

Similar error potential may also exist through inaccurate OE estimates, although in deriving the OE matrix used in the AUC-T calculations (*see* 2007 Annual Report), I attempted to err on the side of conservancy (i.e., to over-, rather than under-estimate OE). Also, population estimates are less sensitive to under-estimates of OE than to similar (percentage) underestimates of SL.

Another potential source of error in population estimates derives from the simplistic approach of dividing total fish days for the season by average weekly SL for the season. This could bias estimates upwards through inordinate weighting of late-season surveys when fish counts are generally highest but SL is often longest. Nevertheless, a potentially more robust approach to calculations, using a more complex AUC method from the literature, has not been adopted. The

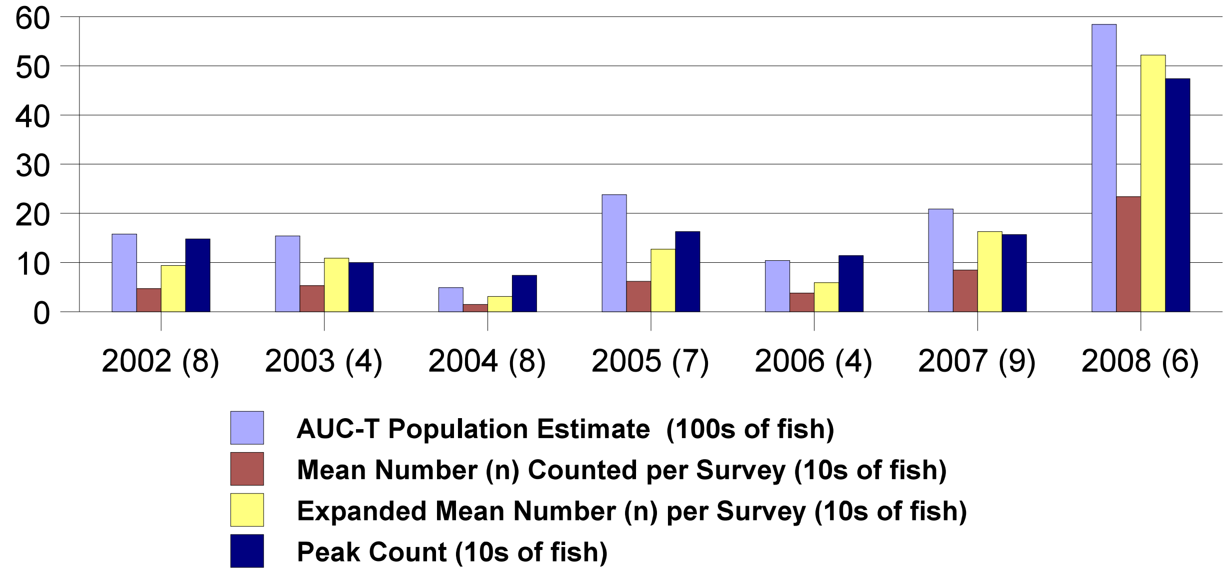

Figure 3. Index Reach spawning population trend of steelhead, 2002-2008, based on AUC-T population estimates compared to mean, expanded mean, and peak survey counts. *(Provisional results subject to revision from further refinement of Observer Error and Survey Life estimates used in AUC-T methodology.*)

present lack of knowledge of OE and SL accuracy obviates such a need. If and when the OE and SL estimation procedures have been sufficiently validated, a more robust AUC calculation approach may be warranted. At such a time, confidence bounds could also be placed on the population estimates.

Thus, it is worth repeating (as discussed in the 2007 Annual Report) that current AUC-T population estimates, including the apparent record 5,843 fish for 2008, are provisional and subject to change as more information is developed. Nevertheless, to help ensure that the 2008 population estimate errs on the side of conservancy, it may be prudent to simply conclude that the 2008 spawning return for the Wheatfield Fork was >4,300 fish (i.e., the estimate in Table 3 for an assumed 25% underestimate of SL, rounded down to the nearest 100).

Population Indices–The large return of adult fish in 2008 was also clearly reflected by the various population indices (Table 3; Figure 3). In particular, the 2008 mean (unadjusted) number of fish counted per survey was 234, compared to a range of 15 (2004) to 84 (2007) and average of 50 for the 6 earlier years. Similarly, the expanded mean number of fish counted per survey (i.e., mean of adjusted [using OE] counts) for 2008 was 522, compared to a range of 31 (2004) to 163 (2007) and average of 97 for the 6 preceding years. And the peak (unadjusted) seasonal count in 2008 was 474 fish (March 23-24), versus a range of 74 (2004) to 163 (2005), with a mean of 126, over the 6 earlier years.

With the addition of 2008 survey results, the obvious relationship trends between annual population estimates and each of the three population indices (as discussed in the 2007 Annual Report) appear to be continuing (Figure 3). However, I have not updated the preliminary coefficients of determination (R^2) values I first report in 2007. I intend to do so after the benefit (from larger sample sizes) of another 2-4 years of data, including improvements to OE and SL estimates, has been achieved.

Snorkeling Surveys

June–The first snorkeling survey of 2008 was on June 16th (Table 4). Up to this date, the watershed had experienced a fairly typical summertime, characterized by cool marine air influence near the coast and gradually increasing ambient air temperatures (AATs) progressing inland. Two high-pressure-aloft-induced heat waves had already occurred, one a 4-day event starting May 15th and the other a 3-day event starting June 11th (FM 89). Maximum daily AATs (i.e., at sites farthest inland from the coast) were generally $\geq 98^0$F during these two heat waves; such high daily AATs cause a dramatic rise in stream water temperatures. Water temperatures can then become chronically high for several days, often to the point of lethality to JSH. How seriously JSH are affected at any particular location, depends upon several related factors, including date (which determines day length), slope (relative steepness), elevation of adjacent terrain, aspect (in relation to sun), degree of riparian cover over the stream, and volume of stream flow.

Based on the record dry springtime (*see* Precipitation and Hydrology, above) and the first two heat waves of summer having already occurred, I was uncertain of what the first snorkeling of the season would indicate. However, I arrived at the stream and began surveys, hopeful of finding a relatively large JSH population–or perhaps a record population–which reflected the large 2008 adult steelhead spawning population.

The first snorkeling sample, at Wolf Creek (site #1), yielded a relatively low total (i.e., compared to previous counts there) of just 82 JSH. However, at the next site (#2), at the mouth of House Creek, the count was a record 3,012 JSH; this was by far the highest value for any 100-ft snorkeling sample I have conducted on the Gualala River to date. Moreover, the total count of 5,498 JSH for all 15 sites, the equivalent of 366/site or 3.7/ ft, was 3.6 times the previous high density recorded in July 2007, and, 5.6 and 15.9 times the density recorded for June surveys in 2007 and 2008, respectively (Figure 4). Nevertheless, despite the high House Creek count and high overall total for all sites, counts at the five estuary sites (i.e., #5a-5d; 9) remained low-to-moderate (i.e., compared to previous counts at *each* site; Table 4).

Stream flows at all 15 sites were already quite low and the Haupt Creek site was developing an intermittent surface flow (Table 4), a very early date for such an event. The South Fork, Gualala stream gage was reading about 4 cfs, while the Navarro River gage at Navarro (an index to the Wheatfield Fork, Gualala flow) indicated about 18 cfs. Throughout the day, significant marine air intrusion (i.e., a noticeable sea breeze) was occurring at all 15 sites. Water temperatures were thus no doubt greatly ameliorated compared to the June 11-13 AAT heat wave, and, at a range of 58-69^{0}F, were within JSH tolerances.

July–The second snorkeling survey was on July 12th (Table 4). During the month that elapsed between first and second surveys, typical summertime weather continued. Two more inland heat waves, with maximum AATs $\geq 98^0$F occurred, one 3-day event starting June 19th and another 6-day event starting July 6th. On the survey date, this second heat wave was just ameliorating, as

Table 4. Flow, water temperature, and JSH counts from three 2008 snorkeling surveys at 15 standard survey sites.[1]

#	Location	16 June Flow	June 16, 2008 Survey				12 July Flow	July 12, 2008 Survey				26 Aug Flow	August 29, 2008 Survey			
			H_20 Temp	Numbers of JSH				H_20 Temp	Numbers of JSH				H_20 Temp	Numbers of JSH		
				YOY	1+	2+			YOY	1+	2+			YOY	1+	2+
1	Wolf Cr.	CF	58	75	5	2	CF	64	250	10	2	CF	63	75	6	3
2	House Cr.	CF	64-66	3000	12	0	CF	67-71	750	0	0	IF	64-66	50	10	0
3	WF Fk. (Ldy)	CF	65	400	50	10	CF	71	150	20	0	CF	69	0	0	0
3a	WF Fk. (Ldy)	CF	65	450	25	0	CF	71	275	10	0	CF	66	0	0	0
4	WF Fk. (Bdg)	CF	69	25	0	0	CF	73	50	0	0	D	67	0	0	0
4a	WF Fk. (Bdg)	CF	69	350	25	5	CF	73	1000	0	0	D	69	0	0	0
4b	WF Fk (Bdg)	CF	68	75	5	0	CF	68	300	10	0	D	65	0	0	0
5a	Nr. N. Fk.-U	CF	69	200	25	2	CF	74	200	10	5	CF	69	300	20	2
5b	Nr. N. Fk.-L	CF	69	25	5	2	CF	74	180	8	0	CF	69	200	12	1
5c	N. Fk. Mouth	CF	60-64	25	0	0	CF	64	30	2	2	CF	64-72	20	0	0
5d	Up. N. Fk. Mo.	CF	64	0	0	0	CF	70	10	0	0	CF	72	6	0	0
6	Twin Bridges	CF	68	75	0	0	CF	68	150	10	0	D	75	0	0	0
7	S. Fork Bridge	CF	63	75	0	0	I F	67	150	0	4	IF	63	100	4	3
8	Haupt Cr.	IF	64	350	0	0	D	--	--	--	--	D	--	--	--	--
9	Hwy 1 Bridge	CF	68	200	0	0	CF	71	150	0	0	CF	76	50	0	0

[1] Descriptions of sample locations are provided in the 2005 annual report and File Memo #060; Flows: CF=Continuous surface flow; IF=Intermittent surface flow; D=Dry–No surface flow, except, in some cases (see File Memos), drying pools; Water Temperatures are maximums, in degrees F, recorded at the sites at time of sampling (*see* File Memos).

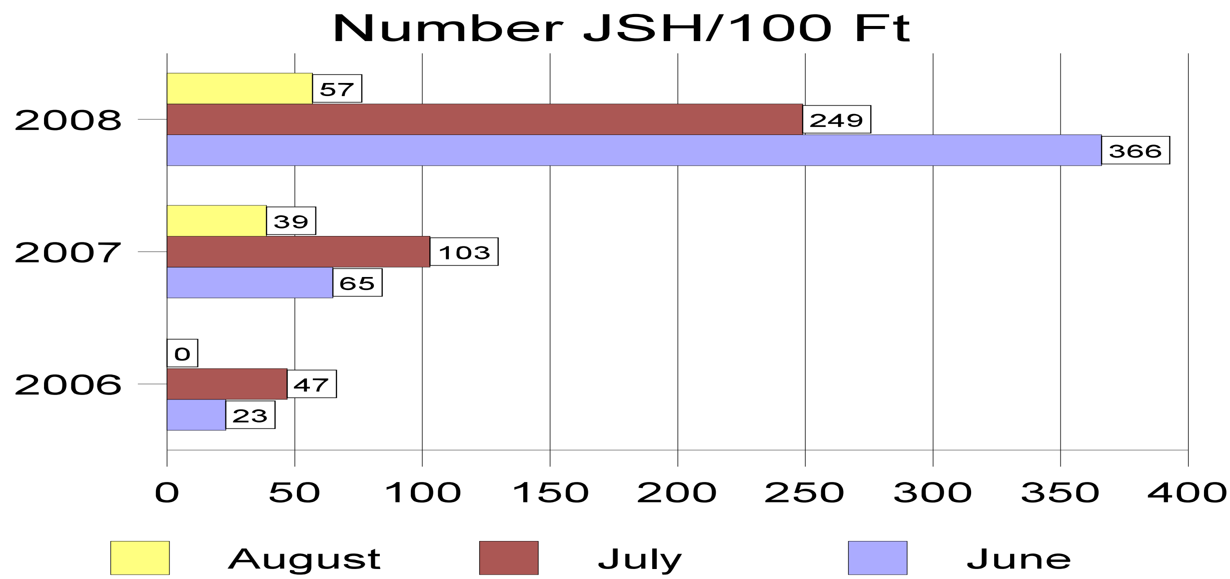

Figure 4. **Gualala River juvenile steelhead (JSH) numbers, 2006-2008, based on one snorkeling survey at each of 15 sites during June, July and August (**No survey in August 2006**).**

significant marine air intrusion had begun extending well inland. Nevertheless, water temperatures, at a range of 64-74^{0}F, remained elevated near upper tolerances for JSH at several of the sites.

Also, stream flows had declined dramatically farther at all sites, with the Haupt Creek site (#8) now totally dry and the South Fork Bridge site (#7) now reduced to an intermittent surface flow. The South Fork, Gualala stream gage was indicating a flow of less than 1 cfs, while the Navarro River gage (index for Wheatfield Fork) was reading about 7.5 cfs. With such dramatically lower flows, JSH rearing conditions had obviously deteriorated markedly since the June survey.

Nevertheless, the total JSH count for the 15 sites was still very high at 3,738 fish. This was the equivalent of 249/site or 2.5/ft, the second-highest density (behind the June values) recorded to date (Figure 4). Two noteworthy changes observed (compared to June values) included 750 JSH (vs 3,012) at the House Creek site (#2) and 1,000 JSH (vs 380) at the Annapolis Road Bridge site (#4a). Such large differences illustrate how JSH distribution had changed over the 1-month period. However, there were still relatively low total numbers of JSH overall–597 (vs 484)–at the five estuary sites. The continuing low-to-moderate density in the estuary suggested that the overall decline of density from June was a true population decline, not merely a population shift to the estuary as upstream habitat conditions deteriorated.

August–The final summertime snorkeling survey was on August 29th (Table 4). During the 7 weeks elapsed between this and the second survey, typical summertime weather continued. Two more inland heat waves, with maximum AATs ≥98^{0}F occurred, one 4-day event starting August 13th and a 3-day event starting August 27th. Thus, the survey occurred just as this second heat wave was ameliorating, due to marine air intrusion. Nevertheless, at a range of 63-76^{0}F, water temperatures were still elevated near upper tolerances for JSH at several sites.

And stream flows had declined dramatically farther at all sites, with five sites now completely dry and two reduced to intermittent surface flows (Table 4). The South Fork, Gualala stream gage was indicating a flow of about 0.5 cfs (a suspect value, given that the stream in the vicinity of the gage was dry), while the Navarro River gage was reading about 1.5 cfs. With such dramatically lower flows, JSH rearing conditions had obviously deteriorated markedly since the previous survey on July 12th.

The total count for the ten remaining sites with any water was 862 JSH. This was the equivalent of 57/site or 0.6/ft (*all* sites considered), values much closer to summertime values for 2006 and 2007 (Figure 4). Only three sites, two in the estuary (#5a, 5b) and the South Fork (#7) site, had ≥100 JSH. The highest count of 322 fish occurred at one estuary site (#5a) near the mouth of the North Fork. While the five estuary sites yielded an overall total close to the July total–611 JSH (versus 597 in July)–the estuary sites now comprised 71% of the 862 total JSH recorded. Clearly, the estuary had become a more important stronghold overall for the remaining JSH population of the watershed than in either June or July.

Nevertheless, 2008 snorkeling surveys also clearly showed that the very large early-season population of JSH–a direct result of a record spawning return–experienced high summertime mortality. This was not unexpected, given the very low flows, extensive dewatering of the stream, and usual summertime heat waves which had occurred. All of these factors worked in concert to dramatically lower the extent and quality of JSH rearing habitat as summer progressed. Water temperatures elevated to lethal levels and loss of stream connectivity necessary for fish to escape hostile areas and move to cool-water refugia were likely two of the most important population-limiting factors.

CONCLUSIONS

- The 2008 steelhead spawning season extended at least 5 months, from December through April, with population peaks in late January and March (highest).

- The various 2008 population indices, including total number of adult fish counted (1,402), mean number counted per survey (234), expanded (based on OE) mean number per survey (522), peak survey count (474), and relative size of fish groups (including eight with ≥40 fish), pointed collectively to a record spawning return on the Wheatfield Fork, the largest of the river's five main branches.

- Based on present AUC-T methodology, the Wheatfield Fork's 2008 spawning population was at least 4,300-5,800 fish, a provisional estimate subject to refinement as estimates of SL and OE integral to calculations are improved in the future.

- Estimation of SL was incrementally improved in 2008, through development of a mathematical function which describes how normal up-and-downstream movements of adult steelhead gradually change to stacking and holding behavior, as the Wheatfield Fork flow declines from 150 to 75 cfs.

- The estimated robust 2008 spawning population for the Wheatfield Fork suggests that the total 2008 spawning return for the river as a whole was likely ≥7,500-10,000 adult fish.

- The estimated robust 2008 spawning population was likely tied to high JSH production in 2005-2006, years with high springtime rainfall which ameliorated otherwise often harsh summertime habitat conditions.

- Just as in past years, most spawning on the Wheatfield Fork in 2008 occurred upstream of the Index Reach.

- Density of JSH in the watershed in early summer 2008 was at a record high, a direct result of a record, large 2008 adult spawner return.

- By end-of-summer 2008, JSH density had dramatically declined to levels similar to previous years, a direct reflection of high JSH mortality, due to harsh habitat conditions exacerbated by record springtime drought.

- Summertime dewatering of the stream in 2008 was the most severe in years, if not decades, and the dewatering phenomenon represents one of the most serious impediments to maintaining and restoring salmonids in the watershed–especially in the Wheatfield and South forks.

LITERATURE CITED

(All reports available on the internet at http://www.gualalariversteelhead.info/)

DeHaven, R. W. 2001. Reconnaissance-level spawning and habitat surveys of steelhead trout, Gualala River, California, 2001. Prepared by the author (Richard_DeHaven@fws.gov), April 2001, for use by agencies, groups and individuals involved in steelhead recovery efforts. 23pp.

DeHaven, R. W. 2002. Steelhead spawning surveys, Wheatfield Fork and other selected reaches, Gualala River, California, 2002. Prepared by the author (Richard_DeHaven@fws.gov or drdehave@hotmail.com), September 2002, for use by agencies, groups and individuals involved in steelhead recovery efforts. 42pp.

DeHaven, R. W. 2003. Steelhead spawning surveys, Wheatfield Fork, Gualala River, California, 2003. Prepared by the author (Richard_DeHaven@fws.gov or drdehave@hotmail.com), December 2003, for use by agencies, groups and individuals involved in steelhead recovery efforts. 14pp.

DeHaven, R. W. 2004. Adult and juvenile steelhead population surveys, Gualala River, California, 2004. Prepared by the author (drdehave@hotmail.com), December 2004, for use by agencies, groups and individuals involved in steelhead recovery efforts. 56pp.

DeHaven, R. W. 2005. Adult and juvenile steelhead population surveys, Gualala River, California, 2005. Prepared by the author (drdehave@hotmail.com), December 31, 2005, for use by agencies, groups and individuals involved in steelhead recovery efforts. 64pp.

DeHaven, R. W. 2006. Adult and juvenile steelhead population surveys, Gualala River, California, 2006. Prepared by the author (drdehave@hotmail.com), December 31, 2006, for use by agencies, groups and individuals involved in steelhead recovery efforts. 47pp.

DeHaven, R. W. 2007. Adult and juvenile steelhead population surveys, Gualala River, California, 2007. Prepared by the author (drdehave@hotmail.com), December 31, 2007, for use by agencies, groups and individuals involved in steelhead recovery efforts. 106 pp.