Radio Telemetry of Steelhead in the North Umpqua River

A RADIO TELEMETRY STUDY OF STEELHEAD IN THE NORTH UMPQUA RIVER BASIN 1998-2001

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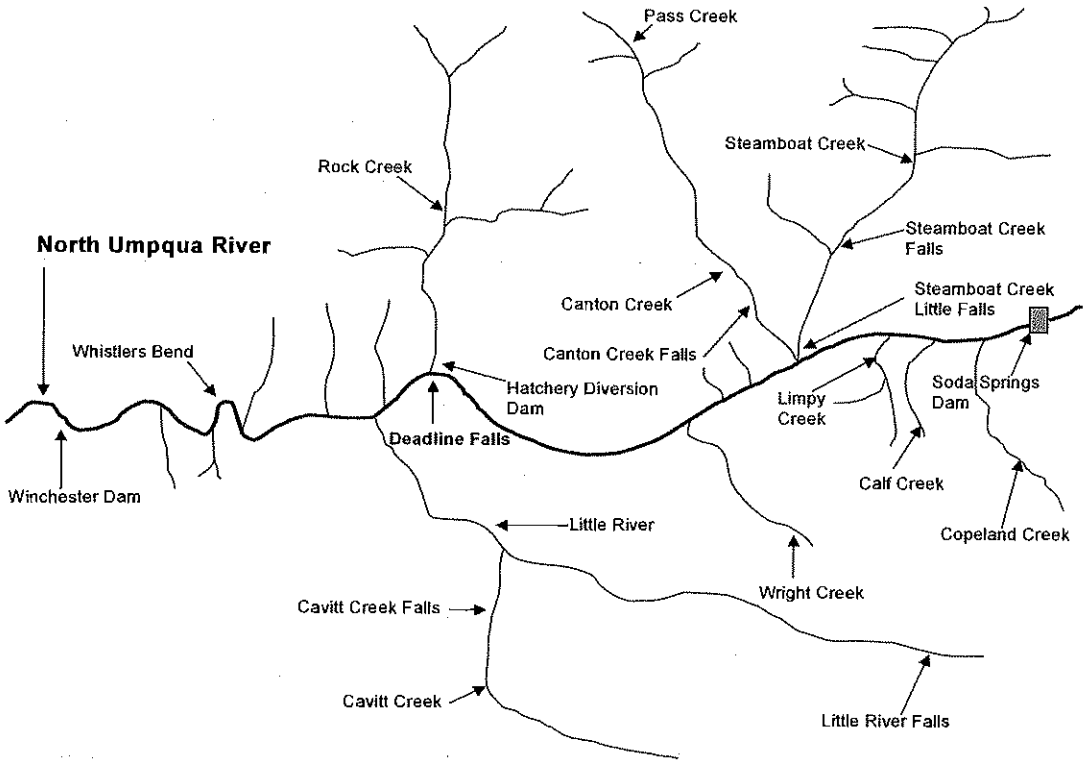
INTRODUCTION

The North Umpqua steelhead (*Oncorhynchus mykiss*) represents one of the few remaining native anadromous fish populations in Oregon still at a relatively healthy level. The sustainability of the North Umpqua steelhead population and its' habitat is a very high priority. The Oregon Department of Fish and Wildlife (ODFW) develops, on a continuing basis, practices designed to ensure the health and viability of this population. However, continued management success depends critically on the availability of data necessary for a detailed understanding of relevant life history issues.

To address these data needs, ODFW began a radio-telemetry study of North Umpqua steelhead in June of 1998. Tagging at Winchester dam was terminated 10/26/00 but monitoring continued until the end of May 2001. This study has provided detailed information on movement patterns of adult steelhead in the basin at a level that is available in no other way and is the most comprehensive project of its type for the Umpqua Basin. A radio tagging study whose scope was limited to the Steamboat Creek subbasin was carried out previously (Wroble, 1990). Also, a previous study of temperature trends in that subbasin is of interest (Hostetler, 1991).

Although similar radio telemetry studies (e.g. Hockersmith et al, 1995) have been carried out in other basins, they are few.

Figure 1. Basin schematic diagram of North Umpqua River and major tributaries.



The headwaters of the North Umpqua River begin on the west slope of the Cascade Mountains, east of Roseburg, OR, as the outflow from Maidu Lake. It then flows 106 miles west to join the South Umpqua River two miles west of Roseburg to form the mainstem Umpqua River. The mainstem Umpqua River then flows 111 miles west to the ocean. Major tributaries to the North Umpqua (Fig. 1) include Little River, Rock Creek and Steamboat Creek, which enter at River Miles (RM) 29.6, 35.75 and 52.75 respectively.

EXPERIMENTAL METHODS AND CONVENTIONS

Radio-tags for use on adult steelhead were purchased from Advanced Telemetry Systems Inc., Isanti, MN. The radio-tags weighed between 20.6 and 21.35 grams and were powered by a 3-V lithium battery with a life expectancy of 310 days. Each tag was encapsulated in a clear, protective epoxy and labeled ODFW with a phone number, return address, and individual frequency. A 30.5-cm wire antenna extended from one end of the cylindrical transmitter, which was 5.5-cm in length and 2-cm in diameter. The tags transmitted a 45-pulse per minute signal on a range between 150.000-150.999 MHz. Telemetry receivers used were model SRX-400 from Lotek Engineering Inc.; Newmarket, Ontario, Canada. Receivers scanned multiple frequencies on the 150.000-150.999 MHz bandwidth, and emitted an audible signal when a specific transmitting frequency was detected. Each fish was tagged with a unique frequency, thus allowing individual identification.

Omni-directional rooftop antennas were mounted on vehicles used for monitoring tagged fish. Portable directional antennas were used for field observations and directional antennas were affixed to an Oregon State Police (OSP) aircraft for flight monitoring.

Steelhead were captured and radio-tagged at the ODFW broodstock collection facility at the Winchester Dam fishway (RM 7). The fish were temporarily held in a separate pool on site for tagging and recovery. A stiff, hollow, plastic tube, extending over the antenna wire, was used to orally insert the transmitter into the stomach of the fish, with the antenna trailing outside the mouth and along the opercle, according to the transmitter attachment method determined to cause the least harm (Mellas and Haynes, 1985). Previous studies report good results using this technique with adult steelhead (Ruggerone et al, 1990; Hockersmith et al, 1995). The recapture of three repeat spawning, anchor-tagged, adult winter steelhead at Smith River Falls (lower Umpqua basin) in 2001further demonstrated that the transmitters did not harm the fish. These fish were radio-tagged and anchor-tagged during the 2000 study year, and were then recaptured in 2001 without the radio-transmitters. These fish were in good condition and exhibited normal growth

Tagged steelhead were photographed and measured (total length) in order to document sex, size and physical condition of each fish, and immediately released to resume their upstream migration. Total handling time for each fish was 2-5 minutes. No anesthetic was used and only fish appearing to be in good physical condition were tagged. During periods of elevated water temperature, fish were tagged early or late in the day to minimize stress. Water temperature, date, handling time, sex, condition, length, and any distinguishing marks (fin clips, seal, net or claw marks, etc.) were recorded during the tagging operation. Fish selected for tagging were representative of the age classes (based on size) present at the time of tagging operations, with a sex ratio of approximately 50/50.

Monthly tagging data for the program are shown in Table 1. An effort was made to tag an equal fraction of the run for each time interval. Since run timing and numbers vary on an annual basis, this could only be done approximately.

Table 1. Total number of steelhead counted at Winchester Dam and number tagged.

	Unclipped						Fin clipped			
	Run			Tags			Run		Tags	
	1998	1999	2000	1998	1999	2000	1999	2000	1999	2000
Jun	1191	538	1164	9	16	14	289	1308	13	17
Jul	1073	1175	1827	10	15	8	1313	2874	26	12
Aug	333	522	482	10	11	7	712	633	9	9
Sep	314	81	328	7	4	8	110	368	5	3
Oct	156	68	303	5	2	5	89	341	5	3
Nov	207	170		4	2		160	45	2	
Dec	215	77		6	4		49	88	3	
Jan	433	674		12	6		41	21	5	
Feb	1441	1314		6	7		32	48	5	
Mar	1693	1947		19	16		37	92		
Apr	1443	1171		12	6		24	33		
May	136	173		2	2		125	119	3	

Tagged fish were monitored 2-5 times weekly primarily by driving along the North Umpqua River, its tributaries, and the mainstem Umpqua. Each detection of a tagged fish was recorded with the time, physical location, habitat type (if possible), signal strength (if unusual) and other applicable

information. Weather and water conditions were recorded at the start of each monitoring day and as necessary if conditions changed. Each tagged fish was monitored during its entire tenure in the basin in so far as possible. Upstream migrants and spawning fish received higher priority for available tracking resources. Kelts (spawned out fish) were tracked when practical.

Road access for monitoring is good throughout most of the North Umpqua basin. Private landowners were extremely cooperative and allowed frequent ODFW access in order to search for tagged fish. However, several "shadows" in the coverage area, due to limited road access, were identified. For example, fish were often "lost" for several days in the 3 miles downstream of Whistler's Bend (RM 22) after being documented just at the downstream end this area. They were not detected above the area until several days later. Several aircraft searches were made in conjunction with the Oregon State Police to search for missing fish in remote or inaccessible areas.

For the purpose of this discussion the data have been divided into 5 segments on the basis that each represents a significant subbasin or a zone that is managed in a substantially different manner. Subbasins include Little River; Rock Creek which includes the basins' only hatchery; Steamboat Creek long considered a critical refuge for summer steelhead; the North Umpqua River below Deadline Falls which is managed to allow multiple types of fishing techniques; and the North Umpqua River above Deadline Falls where only fly fishing is permitted.

The data have been divided into three "Study Years" (SY) (1998, 1999 and 2000) defined as periods beginning the first of June and ending the last day of May of the following calendar year. With the exception of two fish, study years correspond also to brood periods. These two fish, tagged on 6/1/99, spawned and dropped out of the basin in the same month they were tagged. Fish tagged between 6/1 and 12/31 are referred to as "summer" fish while those tagged between 1/1 and 5/31 are referred to as "winter" fish for convenience.

Fish are named "Yxxx-zz" where Y is H for hatchery or W for unclipped fish, xxx denotes the sequence number in which the fish was tagged for a given SY and zz denotes the SY. For example, W001-99 is the first unclipped fish that was tagged in SY 1999.

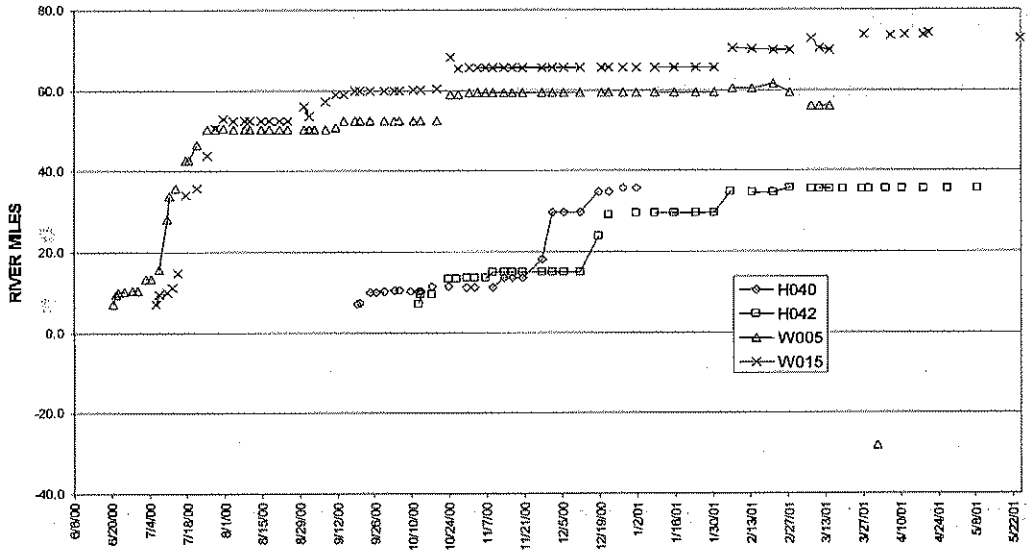
Fish positions were logged in the field as distances from the nearest landmark in the stream. The distance of each landmark from the mouth of the North Umpqua River was estimated by tracing US Geological Service maps. All distances are, therefore, reported as river miles from the mouth of the North Umpqua River and, while internally consistent in this report, may not correspond exactly to other compilations.

Data are summarized in this report for fish that spawned, were caught, etc. These assignments were usually based on behavior and this was not always a clear-cut call. Consider the two fish, W005 and W015, whose timelines are plotted in Figure 2. Both fish entered Steamboat basin during the summer and remained until late spring. W005 left the basin late in the spring and then was detected in the main Umpqua after the end of the spawning season. This fish can reasonably be assumed to have spawned. The transmitter for W015 was still in Steamboat Creek at the end of the monitoring season, an observation that is open to interpretation. Since W015 was in a well-known spawning location when the transmitter ceased moving, this fish also is assumed to have spawned for the purpose of this discussion.

Assignment of a fish as having been "caught" is even more problematic. In some cases first hand reports were obtained and often the transmitter was returned to ODFW. Harvest of a fish can also be inferred from the data as discussed in the following two examples. A hatchery fish, H040 disappeared early in January from the North Umpqua near the mouth of Rock Creek, the area that receives the most intense fishing pressure. This fish was probably caught and harvested. However, it disappeared late enough in the season so that the possibility that it spawned cannot be discounted and, of course, non-human predation is also a possibility. All of these outcomes are also possible for H042, but since the transmitter remained in place until the end of the monitoring season, it's also possible that this fish

died in place or regurgitated the transmitter. It should be noted that evidence exists that suggests that it was not uncommon for fish to be caught and the transmitter left in the water or the nearby brush in this area.

Figure 2. Timelines for four illustrative fish.



Several fish in this study reached a point at which the transmitter remained stationary until the end of the survey period. These are referred to as "deadliners" in the text. H042 in Figure 2 is an example of a deadliner.

Plots of the number of days (or percent of time) various groups of fish spent in sections of the river are presented in the following discussions. Generally the time between two observations was assigned to the first location. When efforts to locate a fish failed for several consecutive trips and the fish was subsequently found in a new location, the time was assigned to the new location if it was deemed appropriate. Fish that had spawned and were returning downstream (kelts) are not included in these compilations.

Table 2 (Appendix) lists the number of fish that spawned in each sub-basin by the month of passage over Winchester dam.

Table 3 (Appendix) contains a rectangle for each fish and each stream in which that fish was observed. Within a rectangle the first and last dates that the fish was observed are listed followed by the maximum distance observed in that stream. Fish that precipitously departed from a spawning area, and were later observed downstream in the same stream, are marked with an asterisk. For these cases, the date of departure from the spawning area is substituted for the actual last date observed in the presumed spawning stream. The first date listed for the North Umpqua is the date the fish was radio tagged at Winchester dam or, for those few fish that were tagged (under a separate program) downstream of the dam, the date the fish passed over the dam.

RESULTS AND DISCUSSION

Steamboat Creek

Steamboat Creek (SC) is a large tributary to the North Umpqua River (NU) at RM 52.75. Canton Creek (CC) is the largest tributary to SC, and enters at RM 53.4. Pass Creek at RM 63.25 is the largest tributary to CC.

Steamboat Falls is a 25' two-step waterfall located at RM 59. A fishway was constructed in 1959 by Oregon Game Commission to improve passage for adult steelhead. SC Little Falls at RM 54.2 (an 8' bedrock step) and CC Falls at RM 54.8 (a 6' bedrock step) are thought to be barriers to fish passage at some flow levels.

Steelhead returning to the SC subbasin crossed Winchester Dam primarily in early summer (Table 2). Of the 67 unclipped steelhead that were radio tagged at the dam in June, July or August and were judged to have successfully spawned, 42 spawned in the SC subbasin. No fish tagged later than mid November entered the subbasin.

Steamboat Creek fish tended to migrate rapidly through the lower mainstem North Umpqua and pass over Deadline Falls (RM 35.85) into the fly angling area, where they spent most of their time

prior to entering the SC subbasin. The number of days spent for each fish in each segment of the NU is tabulated in Table 4 for SY 1999 to illustrate the large variation in behavior. Similar variation was observed for SYs 1998 and 2000. Although the behavior of fish while in the Fly area was diverse, generally the fish behaved as members of one of three more or less distinct subgroups as follows. A few fish do not stage in the NU and proceeded immediately into SC (W011-W043 in Table 4). The largest subgroup (W003-W046) proceeded to the area just downstream from the mouth of Steamboat Creek and staged there for several weeks. A third subgroup (W004-W040) tended to hold at other locations in the Fly area. The latter two groups moved into SC on late summer or early fall rains as discussed below. Keeping in mind that fish were labeled in sequence from the beginning of the SY, one can see from Table 4 that the groups are not clearly separable in terms of the time period in which they were tagged.

For SY 1999, an average fish in the SC group spent 71% of the total time it was in the North Umpqua, in the Fly Water. It's noteworthy that 10% was spent in the 2 miles just below the mouth of Rock Creek, an intense bait fishing area, and 41% was spent in the 2 miles just downstream from the mouth of SC, an intense fly fishing area.

Table 4. Days spent in segments of the North Umpqua for the SY 1999 Steamboat Creek fish. River miles are grouped in 3-mile segments and chosen to provide a division at the beginning of the Fly water (RM 35.8). CC denotes Canton Creek fish.

RM		5.8	8.8	11.8	14.8	17.8	20.8	23.8	26.8	29.8	32.8	35.8	38.8	41.8	44.8	47.8	50.8	Total	LNU	Fly
W011		2	7								6		2			1	12	30	15	15
W018		9			1			3	2		15			2			5	37	30	7
W030			5		1		3			2	7					4	13	35	18	17
W038		1	3	8	6											12	2	32	18	14
W043		3	18						3	3	5							32	32	0
W004		29					5				10		6			52	8	110	44	66
W017	CC		3		3		3		1	3	7	88		1		1	13	123	20	103
W019		1	9	0	0		0				5	0	8	1	2	57	5	88	15	73
W032	CC												33		1	22	9	65	0	65
W036			6				1		1		36		3		7	10	18	82	44	38
W040	CC	8					1	1	0	2	4		12	2	10	12	16	68	16	52
W003		18		1			2				5				2		79	107	26	81
W013		3	12				2		3		4		3	7	3	4	78	119	24	95
W014			3	3	3		1	2			3	7					39	61	15	46
W020		1	4		5			0	1		22	6			4		65	108	33	75
W022	CC		11								15	4		3	4	16	55	108	26	82
W024		1	9	5					1		7	3		1	3		78	108	23	85
W025		1	1	4	3				3		3	3			4	2	47	71	15	56
W029			2	3			2		1		7			3			59	77	15	62
W042	CC	3		11	6				13					1	2		36	72	33	39
W046	CC		14	5			2	0	3		11				1		139	175	35	140

The data plotted in Figure 3 indicate that the holding patterns in the North Umpqua are similar for the three SYs of this study.

Figure 3. Average # of days/mile per fish in NU for SC spawners.

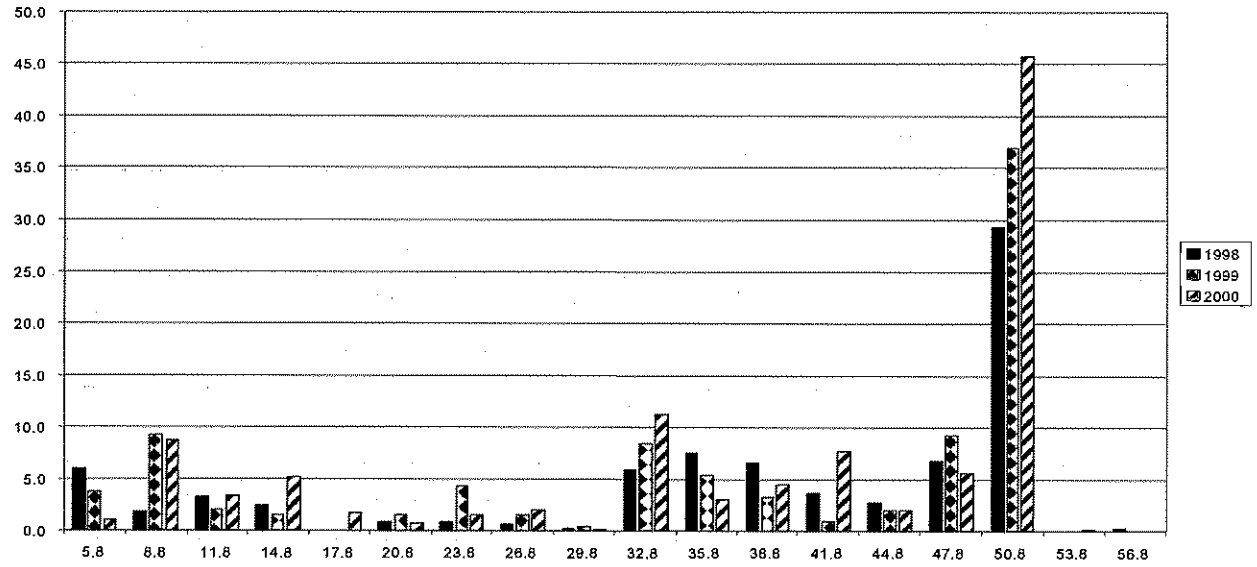


Table 5 lists the date fish were first detected (DOE) in Steamboat Subbasin. Fish marked under SB with a "CC" spawned in Canton Creek, the two labeled "Fly" returned from extended stays in the subbasin to spawn in the upper NU and the others spawned elsewhere in the subbasin. The values listed under "Days" are the number of days spent at base of barriers. In the case of CC spawners the barrier was Canton Cr. Falls and for the others it was Steamboat Cr. Falls. An * indicates fish that never crossed the barrier. W013-98 spent 44 days at the base of Steamboat Cr. Falls and W012-99 spent 75 days below Canton Cr. Falls before returning to the NU to spawn.

Comparisons of the timing patterns for fish entering the subbasin with changes in flow are interesting.

Table 5. Date fish were first detected (DOE) in Steamboat Subbasin.

	SY	1998					1999					2000	
Name	SB	DOE	Days		Name	SB	DOE	Days		Name	SB	DOE	Days
W007		7/14	0		W011		7/25	0		W006		7/16	0
W005		7/17	0		W018		8/25	0		W003		7/28	0
W011		9/14	0		W014		8/31	0		W009		8/21	0
W006	CC	9/18	31		W030		8/31	0		W015		9/1	0
W015	CC	9/21	2		W038		9/4	0		W028	CC	9/29	20
W014		9/23	0		W004		10/6	0		W005	CC	10/24	0
W008		9/27	0		W025		10/6	0		W014		10/24	0
W004	CC	10/12	0		W019		10/8	0		W016		10/24	0
W028	CC	11/18	0		W003		10/12	0		W017	CC	10/24	0
W045*	CC	2/19	52		W029		10/12	0		W020		10/24	0
W037		3/12	0		W013		10/28	0		W026	CC	10/24	0
W013*	Fly	10/16	44		W020		10/28	11		W027	CC	10/24	3
					W022	CC	10/28	10		W034		12/19	85
					W024		10/28	0		W007*		3/20	7
					W032	CC	10/28	0		W021	CC	3/20	0
					W036*	CC	10/28	237		W042		3/20	30
					W040	CC	10/28	0					
					W042	CC	10/28	0					
					W043		10/30	4					
					W017	CC	11/12	0					
					W046	CC	3/16	14					
					W012*	Fly	11/26	75					

Provisional flow data for Steamboat Creek were obtained from the US Geological Survey and are plotted in Figures 4 and 4a. Comparing the flow data with the movement of fish for SY 1999, it's clear that fish tended to enter the basin on flow increases. W011-99 is a notable exception. This fish arrived at the confluence on 7/11, remained there for about 2 weeks and then was detected in SC on 7/25. There is no discernible increase in flow on or immediately preceding this date. Also of interest is the observation that W014-99 was in position at the same location by 7/23 but didn't proceed into SC until 8/31. The movement of all subsequent fish can be associated with increases in flow except for W046, which moved into SC in mid-March at what appears to be a local minimum in flow. In nearly all cases, however, there were several fish within 0.2 miles of the mouth of SC that remained in place while others migrated during significant hydrologic events. Similar comparisons are easily seen for SY 1998 and SY 2000.

It is interesting to note that there was no migration of radio tagged fish into the SC subbasin that could be associated with the temperature minima that occurred on 8/7 and 8/14 (Figure 5). Indeed, even though the water temperature suddenly dropped below 60 degrees for the remainder of the season in late August, fish generally remained in staging position until flow increases occurred.

Figure 4. Flow for Steamboat Creek during SY 1999.

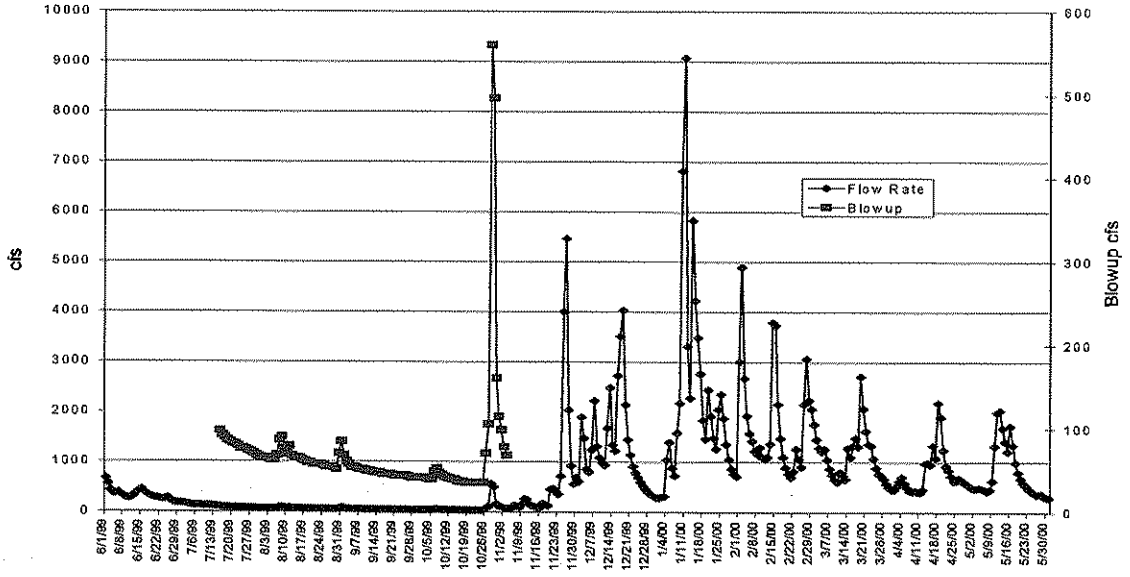


Figure 4a. Flow for Steamboat Creek for July through December of SY 1998 and 2000.

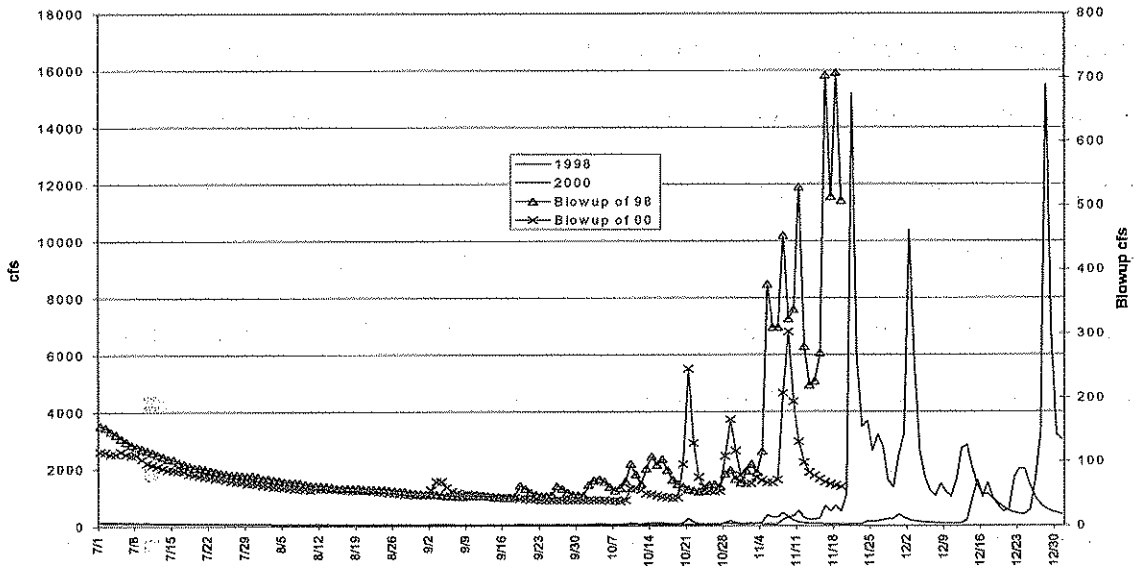
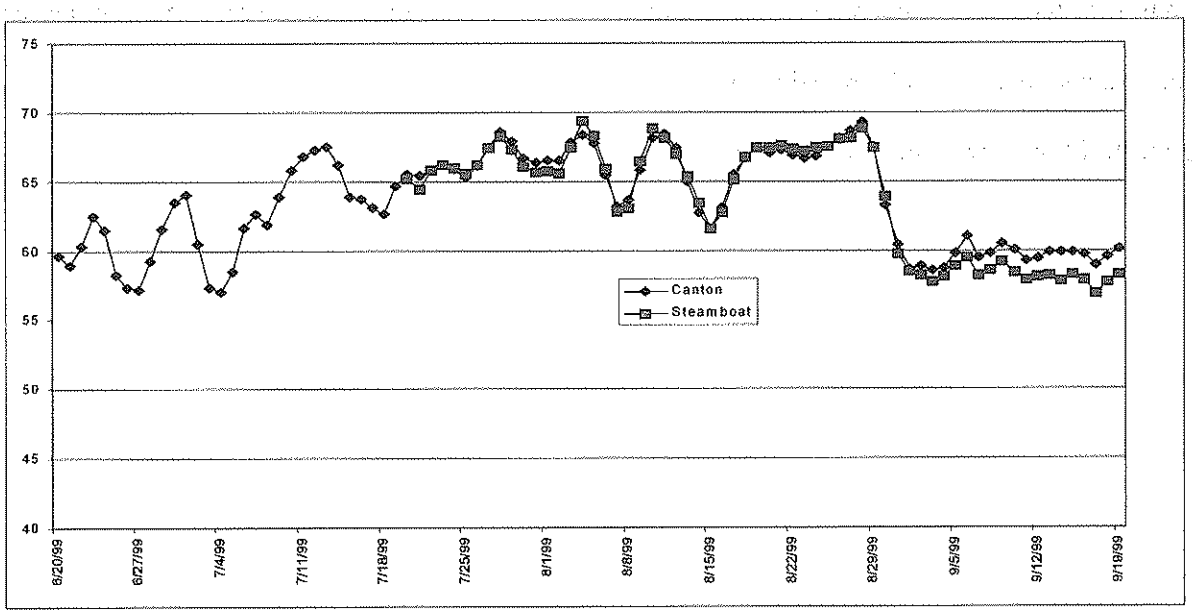


Figure 5. Mean daily temperature measured in Canton Cr. near the mouth and in Steamboat Cr. just above the mouth of Canton Cr (Smith, 2002).



Fish destined for Canton Creek entered the subbasin later than the SC spawners and appear to have waited for a more significant increase in flow before leaving their staging area in the North Umpqua. More detailed examination of the data than can be presented here shows that only rarely did a Canton

Creek fish proceed into Steamboat Creek on earlier events and those that did returned immediately to the North Umpqua.

Steamboat Little Falls presents a problem for only a few upstream migrating fish (Table 5). One fish, W013-98, spent 44 days at the base of SC Little Falls and then returned to spawn, just above the mouth of Steamboat Creek, in the North Umpqua. Another, W034-00, held 85 days at the falls before passing over and spawning upstream. W042-00 spent 2 weeks below the falls then was observed 3 miles upstream. This fish then returned to the base of the falls for 2 weeks and was seen again one final time about 3 miles upstream. W007-00 was never detected above the falls and appears to have spawned just below it.

Canton Creek Falls seems to be more of an obstacle to upstream passage. W012-99 spent 75 days at the base of Canton Creek Falls before returning to spawn in the North Umpqua. The signal for W036-99 was first detected at the base of the falls in early October and remained there until the end of the survey period. W045-98 spent approximately 3 months at the base of the falls (and perhaps spawned there) and then suddenly disappeared from the area. The remainder successfully traversed the falls, albeit after several days in some cases.

Figure 6. Plot of the total number of days spent by fish in various sections of Steamboat Creek. Does not include time in tributaries.

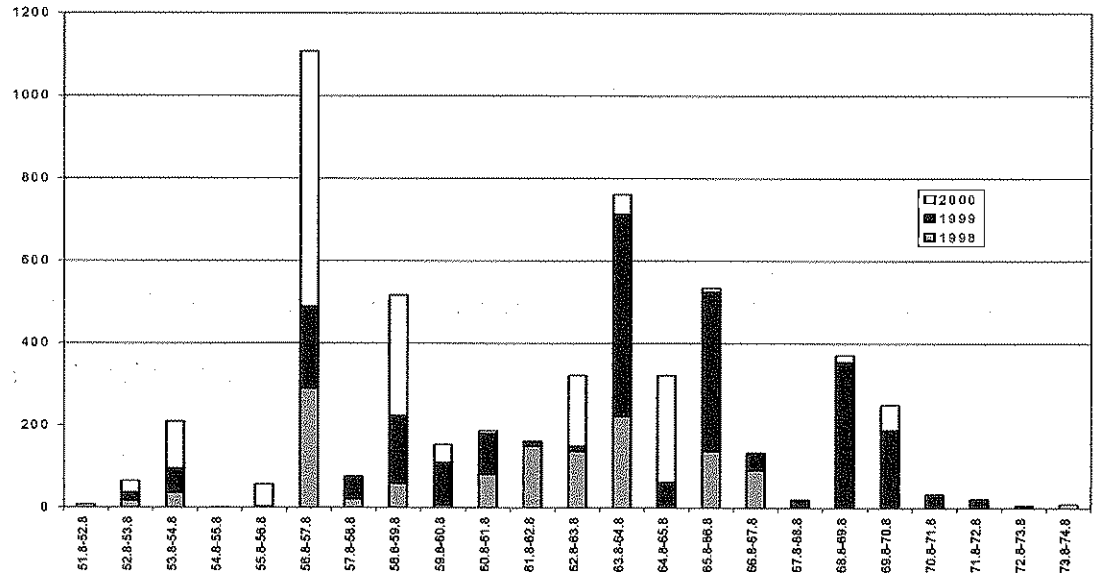
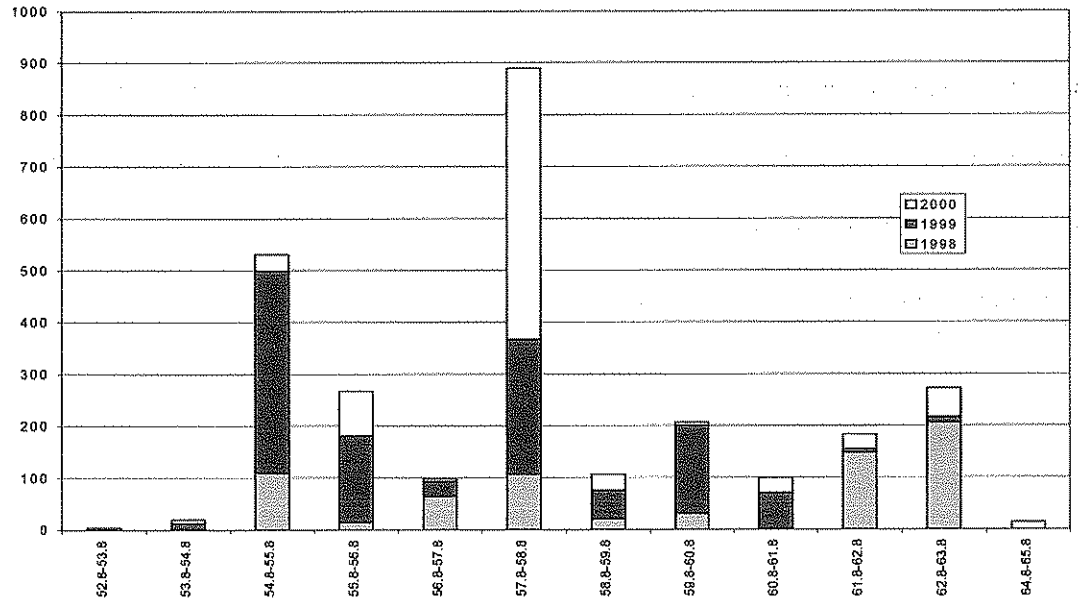


Figure 6 indicates several areas where steelhead hold in mainstream Steamboat Creek. The largest peak, in the mile section beginning at 56.8, corresponds approximately to the confluence with Black Creek. This area is in a deep canyon often referred to as "Black Canyon". The peak in the 58.8 interval corresponds to Steamboat Falls and the interval beginning at 63.8 includes two well-known holding holes just below the confluence with Big Bend Creek. Other peaks in the histogram correspond to the mouth of Little Bend Cr. (RM 66.3) and Cedar Cr (RM 66.6) as well as Little Rock (RM 70.5) and City (RM 70.8) Creeks. ODFW currently conducts annual fish count surveys of several well-known holding pools in this area during the summer and fall to provide population trend data. The results of the survey studies are consistent with the data shown in Figure 6.

Figure 7. Plot of the total number of days spent by fish in various sections of Canton Creek. Does not include time in tributaries.



The major peak in Figure 7 occurs for a section of Canton Cr. that includes the "Five Mile Hole", a well-known holding pool for summer steelhead. Canton Creek Falls is at RM 55.0. These data are, as is the case for Steamboat Creek, consistent with the fish counts conducted by ODFW in CC pools several times during the summer.

Spawning occurred in several tributaries of SC and in Pass Creek, a tributary of CC. During SY 1998 fish spent periods of time during the spawning season in N Fork Cedar Cr. (1 fish), Pass Cr. (2) and Big Bend Cr. (1). During SY 1999, fish probably spawned in N Fork Cedar Cr. (1), S Fork Cedar Cr. (1), Cedar Cr. (2), Little Rock Cr. (5) and Horse Heaven Cr. (1). For SY 2000, fish were detected, during the spawning period, in the tributaries Horse Heaven Cr. (1) and Cedar Cr. (1).

For those fish that did not spawn in tributaries, spawning appears to have occurred, from Figures 6 and 7, beginning at Black Canyon in Steamboat Creek and at Canton Creek Falls in Canton Creek. Of those fish that spawned in mainstream CC only one spawned above Pass Creek.

Table 3 lists the date the signal for each fish was last detected in each stream and, therefore, can be used to estimate the out migration pattern after spawning. Though a few fish migrate out earlier (January or February), March and May are major exodus months and the peak appears to be in April.

Overall, two results emerged from this study that are key to the management of Steamboat subbasin fish. The first is that no radio tagged fin-clipped fish entered the SC basin. Secondly, no fish tagged after mid November entered the subbasin. That is, this subbasin appears to be habitat for a purely summer, wild population. That winter fish do not utilize this spawning area is interesting. Although, historically, Steamboat Falls may have been a barrier to migration at winter flow levels, the excellent spawning beds below the falls and, indeed, the whole of the Canton Creek basin are clearly accessible to winter fish.

Finally, it's worth emphasizing that of the 90 unclipped fish tagged during the course of this study between June 1 and the end of November 48 of them spawned in the Steamboat Creek basin.

Little River

The confluence of Little River (LR), a large tributary, with the North Umpqua River is at RM 29.6. Little River Falls is an approximately 10-foot bedrock step, located at RM 48.1, and is laddered. No other barriers to anadromous fish passage are known to exist between the mouth and Little River Falls.

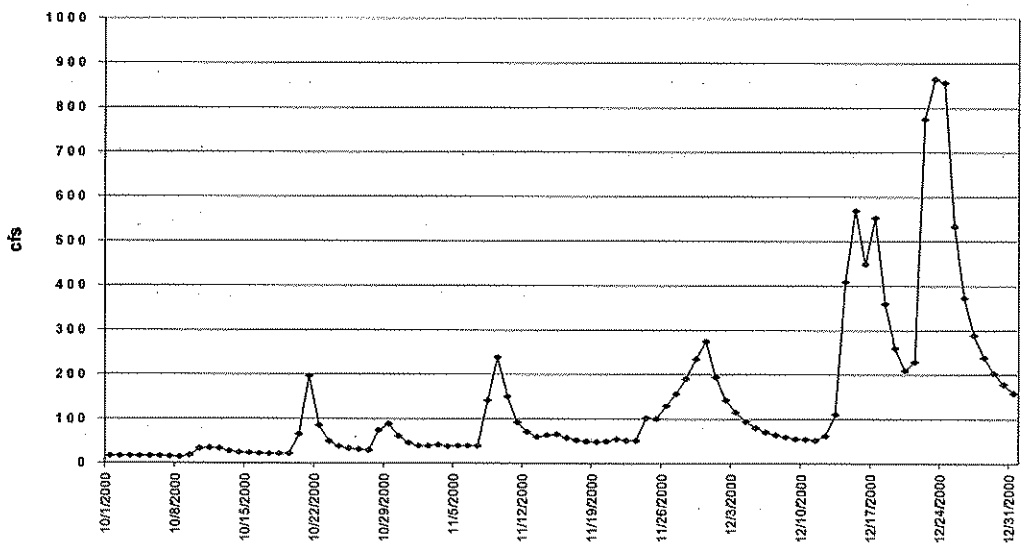
Black Creek at RM 50.3 is thought to be the current upper limit of anadromous fish distribution. The largest tributary to Little River is Cavitt Creek, which enters at RM 36.8. Cavitt Creek Falls, a potential barrier, is located at RM 40.2

Sixteen unclipped and one hatchery radio tagged fish apparently spawned in LR subbasin during the study. Eleven fish spawned in mainstream Little River, five in Cavitt Creek and one in Jim Creek. Since the number is small, quantitative conclusions drawn on the basis of these data must be regarded as tentative at best. It is perhaps significant, however, that over half (9) of the LR fish passed over the dam in December or January (Table 2). The fact that 29 fish were radio tagged during that period suggests that around 30% of the total run during the period was destined for Little River. Two March RT fish, W073-98 and W070-99, spawned in LR during the study. Both fish spawned low in the subbasin and stayed for only very short periods of time. Four fish tagged during the late summer or early fall, plus four tagged in December, spawned in the Little River subbasin suggesting that it is a significant spawning area for fish that can be thought of as part of the NU "summer" run.

Three of the five Cavitt Creek fish spawned near RM 46 and of the eleven Little River fish, six spawned near RM 46. No radio tagged fish passed over Little River Falls. One of the Canton Creek spawners (H072-99) was the only hatchery fish to be observed in the subbasin. This fish was a stray from a hatchery augmentation program on the South Umpqua River rather than a fish that was released into the NU.

Flow data indicate, as one would expect, that significant hydrologic events occurred more or less simultaneously throughout the basin. Therefore, data presented for SC in Figures 4 and 4a are relevant to LR as well. However, in general, LR flows are lower than those for SC and typically drop to less than 20 cfs late in the summer. Actual values for Little River during part of SY 2000 are given in Figure 8 and can be compared to Figure 4a to obtain a rough scale factor for estimating flow magnitudes for LR from SC data.

Figure 8. Flows for LR during the fall and early winter of 2000.



In a manner consistent with the behavior of Steamboat Creek fish, the four LR fish that passed over the dam during the late summer or early fall staged for periods of weeks or even months in the North Umpqua until a significant increase in flow for the LR drainage occurred. By the time fall rains occur the LR water temperature typically drops to less than 55 degrees (Jones, 2001), implying that the impediment to migration into LR was not related to temperature but rather to water flow levels as is the case for the Steamboat Creek area.

W025-98 staged at the mouth of LR beginning on 9/6. This fish was last observed in the NU on 10/09/98 (Table 3) just before a significant local maximum on 10/10 after having ignored three earlier events that peaked at flows that were about 60-70% of that maximum. W041-99 was first observed at the mouth of LR on 10/7/99 and was first detected in LR 10/29/99 on the major early flow increase that also stimulated a large group of fish to enter SC. Two LR SY 2000 summer fish crossed the dam in the first 3 weeks of September and, again, entered LR on a more major increase in flow after ignoring earlier, smaller increases (see Table 3 and Figure 8). Both of these fish staged for several weeks (about 10 weeks) about 5 miles downstream from the confluence of LR with the NU and both spawned in Cavitt Cr.

Out migration appears to begin in early February and continue through mid April for this system, as is the case also for SC.

The behaviors of five fish are relevant to the question of whether Cavitt Cr. Falls presents a significant barrier. W052-98 spent about one week at the base of the falls and W062-98 spent 2 weeks before passing upstream. Of the remaining three fish, one passed over the falls without detectable delay and the other two spawned downstream from the falls without ever approaching it.

Rock Creek

The confluence of Rock Creek (RC) with the NU is at RM 35.75. The primary potential barrier to fish migration is the RC hatchery diversion dam at RM 36.

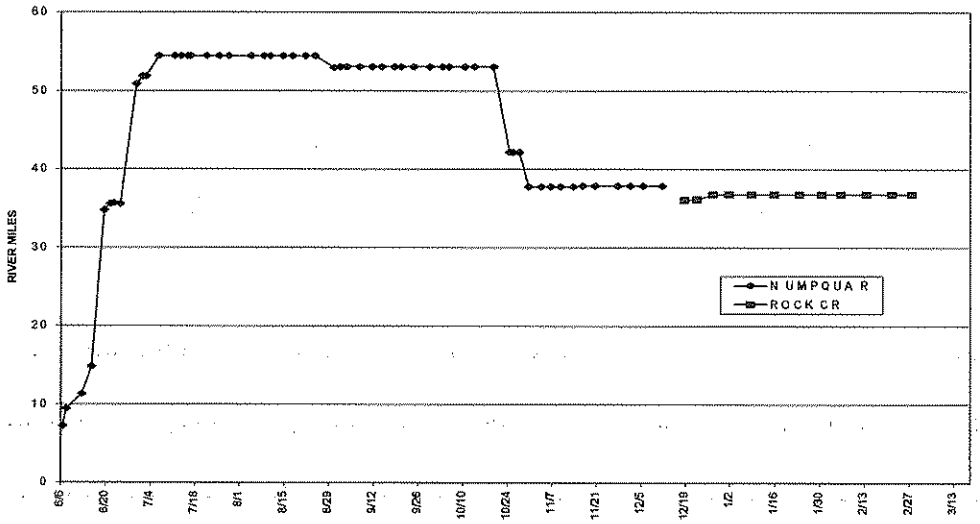
From the data in Table 3 one sees that of the 36 fish that exhibited spawning behavior in the RC basin, 26 can be classified as a summer fish in the sense that they crossed Winchester dam before December 31st. Seven fish can be thought of as late winter fish. These fish crossed the dam in March or April and exhibit time lines typical of fish returning in that period. That is, they proceed rapidly upstream, spawn and return in a very short time. Indeed, some were detected for less than a month in the NU system. Two fish that were tagged in January or February, H064-99 and H073-99, were fin-clipped in a way that identified them as strays from the South Umpqua hatchery augmentation program. Fish W047-00, which passed over the dam on 2/6/01, is the only other fish in the RC group that can be counted as an early winter fish. The RC run can then be characterized as a strongly summer run with an additional significant peak in late winter, but missing the strong mid-winter component of the overall NU run.

Comparison of the dates fish were first seen in RC (Table 3c) with the flow graphs show that the RC fish tend to enter the system on substantial flow increases in a manner similar to that discussed for SC and LR.

Interestingly, four RC spawners migrated up the NU and beyond the mouth of RC by several miles and then returned to RC on what appear to be rather minor freshets. Several hatchery fish that were

eventually harvested also intruded into the Fly water and then dropped back on a fall rain to be caught lower in the NU, usually in the vicinity of the RC pool (see above). The timeline for W004-00, the only unclipped fish to exhibit this behavior, is illustrative of this behavior pattern and is shown in Figure 9. This fish proceeded rapidly upstream from the dam and, after a brief pause at the mouth of RC, continued briskly to a point (RM 54.5) about 2 miles above the mouth of SC where it remained until the first week in August. During the first week in August it restaged at RM 53.1, about .3 mi above the mouth of SC, a location at which it was last observed on 10/19. Note the freshet (Figure 4a) that began on 10/19/00 and peaked on 10/21. After a brief pause at RM 42.2 the fish was next detected at RM 37.8 on 10/30 where it remained until it entered RC in mid-December. Drop back dates for H006-99, H019-99 and H030-99, the other RC spawners that intruded into the fly fishing only area, are 10/6/99, 11/20/99 and 10/4/99 respectively and each entered RC only a few days thereafter. The maximum distances that these 3 fish achieved in the NU are RMs 44.0, 46.3 and 40.8 respectively.

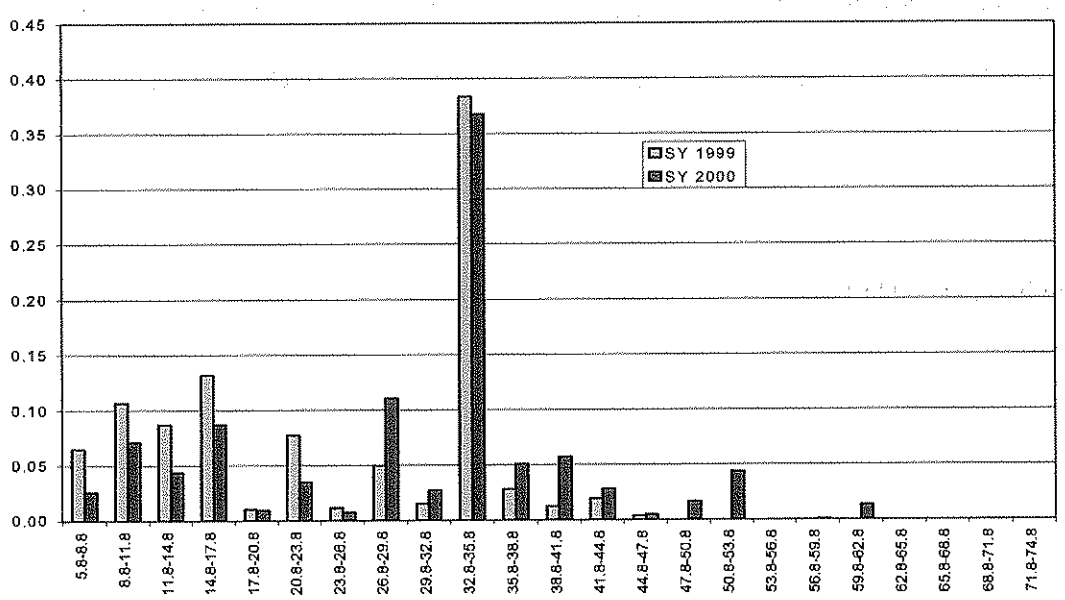
Figure 9. Time line for W004-00



The fact that hatchery fish that venture into the fly water return to Rock Creek on the fall rains has obvious management implications.

The time spent in the NU by RC spawners varied from 7 to 150 days with the shorter times posted by one (H004-00) early and several late winter fish. The fraction of time spent in each NU 1 mile section is shown in Figure 10 and is obviously heavily weighted toward the 2 miles just below the mouth of RC. The patterns are roughly similar for the two study periods in which hatchery fish were tagged though there exists a wide variation in individual fish behavior. For example, the peak for SY 2000 at 6.8-7.8 miles is primarily due to one fish that spent 121 days there. Total number of days spent in the NU for RC spawners are 156, 1652 and 878 for SY's 1998, 1999 and 2000 respectively. No fin-clipped fish were tagged for SY 1998.

Figure 10. Fraction of time RC spawners spent in sections of the NU.



As to the issue of the RC diversion dam as a barrier, we note that fish often approached the base of the dam, sometimes several times, and then returned to the NU to be caught or to spawn. On the other hand, many of the fish that did traverse the dam spent very little time at the base of the dam and presumably cleared it with little difficulty.

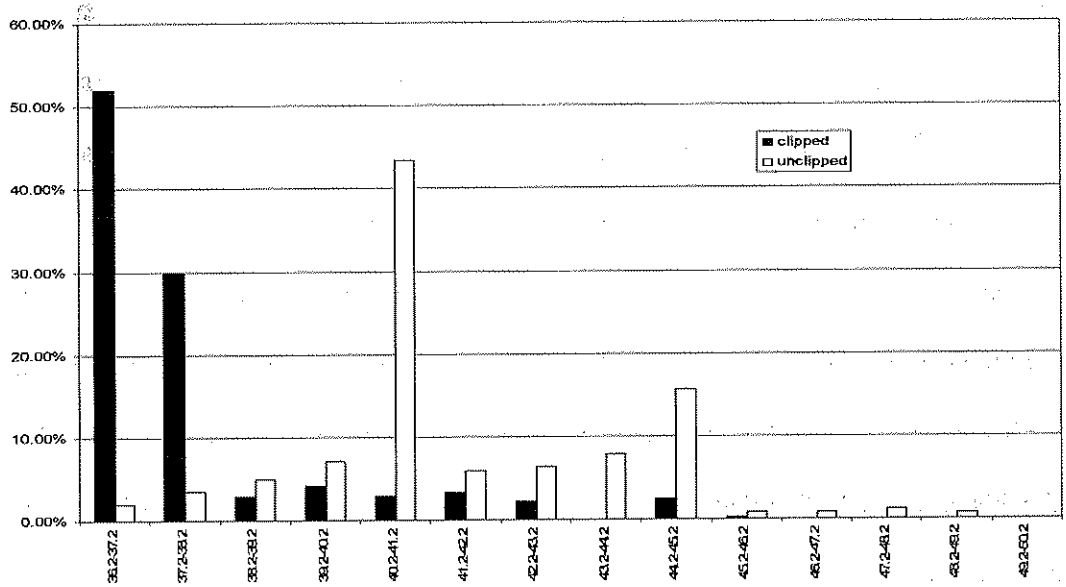
In SY 1998 five fish that entered RC but did not appear to spawn there spent time at the base of the dam and then backed out to the NU, three of these made two such trips. Of these five, four were either reported caught or could be inferred from the data to have been caught. The remaining fish appears to have dropped back and to have spawned at NU RM 22. Of the six fish that entered RC and that did appear to spawn there, (see Table 3c) three achieved a maximum distance that would place them above the dam. These 3 fish averaged 7 days at the base of the dam.

For SY 1999, 13 fin -clipped and 7 unclipped fish appear from the data to have spawned in RC, 16 of them above the dam. Of the 4 that were never observed above the dam, W076 and W082 were spring fish that progressed to the base of the dam in a few days, remained there for 20 and 9 days respectively and then disappeared from the area. One of these fish was subsequently observed near Winchester dam, presumably as a kelt. H038 spent 2 periods of several weeks at the base of the RC dam and dropped back to the NU both times. On the third approach the transmitter remained in place until the end of the survey season. None of the fish that spawned above the RC dam appear to have exhibited this behavior of approaching the dam and dropping back to the NU. Average retention time at the dam for this group of 16 fish that spawned above the dam was slightly less than 3 days, the longest being 15 days.

For SY 2000 two fish entered RC but were judged not to have spawned there, and therefore are not listed in Table 3c as RC spawners. One disappeared at the RC dam on 11/16/00, a date which is probably too early to have permitted spawning. The other popped into RC to be observed once early in the summer and then dropped back to the RC pool in the NU to be caught in April 2001. Two fish that did not traverse the dam but may have spawned there are H029 and H044. H044 dropped back to the NU on 1/23 and was subsequently seen several miles downstream. H029 deadlined at the face of the dam. For fish that successfully traversed the dam the average retention time at the dam was 4 days excluding H004 for which the data are incomplete.

Inspection of the maximum distances achieved for spawners in RC (Table 3) indicates that there is some overlap in spawning territory between clipped and unclipped fish although unclipped fish appear to have spawned higher in the basin on the average. Also, there is considerable difference in the percentage of time spent in various sections of the stream for the two classes. This is illustrated in Figure 11 for SY 1999 and is typical also of SY 2000.

Figure 11. % of time spent in various sections above RC dam in SY 1999. Total days are 745 for unclipped fish and 625 for clipped.



Lower North Umpqua Area

The Lower North Umpqua Area includes the section of the NU, and its tributaries, between Winchester dam (RM 7.2) and Deadline Falls (RM 35.8), excluding Little River and Rock Creek subbasins. The major tributaries include Dixon (RM 17.1), Clover (RM 18), Oak (RM 20), Bull (RM 21.2), Jackson (RM 23.8), Cooper (RM 23.9), Huntley (RM 26.1), Fordice (RM 28.1), Bradley (RM 30.6), French (RM 30.9), and Britt (RM 33.3) Creeks. Several of these appear to contain suitable steelhead spawning habitat and, indeed, several of them are known coho salmon spawning streams. Bait fishing is allowed in this section and fishing pressure is intense between the mouth of Little River and the boat ramp at Whistler's Park (RM 22.3) and, especially, in the 2 miles from the mouth of Rock

Creek downstream. There are no public boat ramps between Whistler's Park and the Page Road ramp at RM 9.4. This section receives less fishing pressure due to the longer drift and the fact that it requires a higher level of boating skill to safely traverse it.

Data presented in Table 2 suggest that the run appears to peak in March and fish that spawn in this section are predominately unclipped winter fish. The data also suggest that approximately one-third of the entire NU winter run utilizes the lower NU Area for spawning.

Of the three unclipped and one clipped early summer (June-July) fish that were judged to have spawned in this section, two are less than certain. H024-99 disappeared very early in the spawning season in a region where fishing pressure is intense, and W015-99 deadlined less than 7 miles above the dam. W001-99 and W002-99 were tagged on 6/1/99 and were observed to have dropped out of the system a few days later. These then are not "summer" fish, but rather late spring fish from the previous brood year.

Some of the shortest residence times for the basin were recorded for this section. Notice W090-99 and W091-99, each of which spent 5 days between the time they were tagged and when they dropped back exhibiting behavior typical of a kelt. Both progressed steadily upstream and were observed only once at their respective maximum position.

W051-99, a fish that spawned in Cooper Creek, is the only fish documented to have spawned in a tributary of this section. This fish was tracked to a pool 1.7 miles upstream from the mouth of the creek that was observed to contain several other steelhead. Cooper Creek is a very small seasonal stream for which there is no visible outflow during most summer months. The lower NU tributaries are primarily on private land and most do not have roads that parallel them, making tracking more difficult. Indeed, several instances can be found, in the detailed data available on CD-ROM, where a fish was observed near the mouth of a tributary, not detected for a survey trip or two and then reappeared near the tributary mouth where is was last observed. These fish may have spawned in the tributary during the period they were looked for but not found.

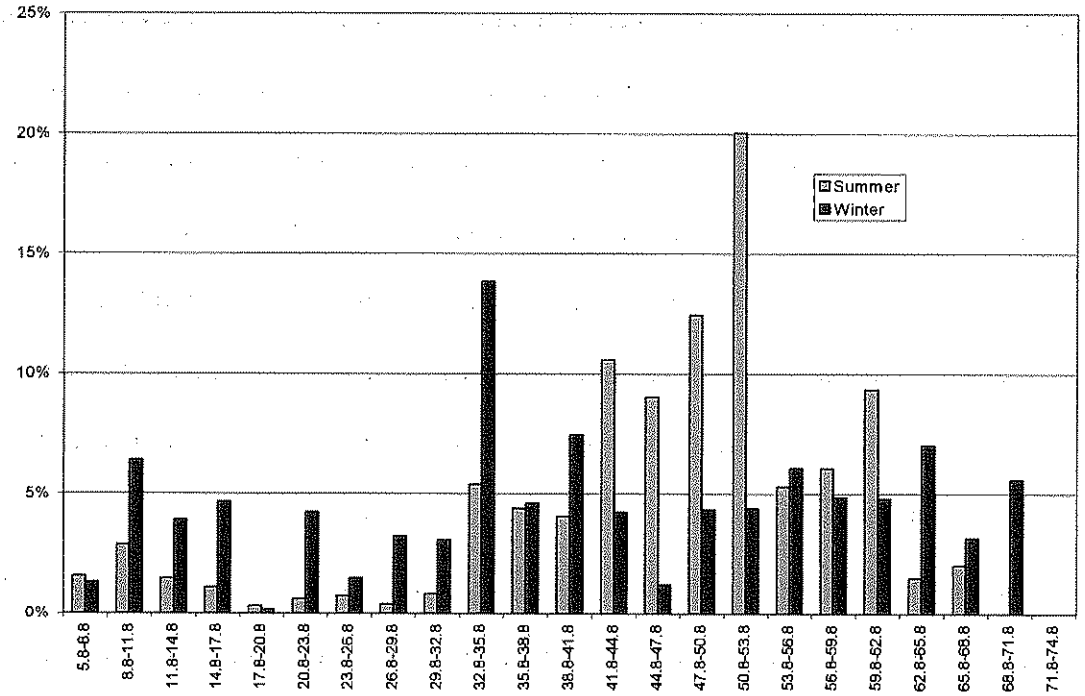
Fly Area

The Fly Area includes the North Umpqua Basin above Deadline Falls (RM 35.8) and all tributaries excluding the Steamboat Creek Subbasin. Fishing is allowed in the main river but is restricted to the use of artificial flies.

In terms of timing over the dam, this group of fish roughly mimics the temporal characteristics of the overall population with a summer subgroup that peaks in June or July and a winter subgroup that peaks in March. Neglecting the only 2 clipped fish to spawn in the Fly Area during the course of the study, 21 of the 98 spawners tagged during the months June-December and 36 of the 78 spawners tagged during the months January-May spawned in the Fly Area.

Plots of the time unclipped fish spent in sections of the NU (Figure 12) show markedly different patterns for summer and winter fish. Summer fish migrate quickly to the area above Deadline Falls and then distribute fairly broadly in the Fly Area with a peak around RM 60. Winter fish appear to spend a larger fraction of their time downstream from Deadline Falls and slightly more time in the upper reaches of the Fly Area (above the confluence with SC) than do summer fish.

Figure 12. Percent of days unclipped Fly Area fish spent in sections of the NU.



Tributaries to the NU in which Fly Area fish were documented, and where they possibly spawned, during this study are Susan (RM 42), Wright (RM 48), Limpy (RM 57.2), Calf (RM 61.4), Dry (RM 62.2), Copeland (RM 66.2) and Boulder (RM 67.6) creeks. Some Fly Area spawners intruded into tributaries, namely Fall (RM 32.5), Steamboat, Canton, and Rock Creeks, before returning to the NU to spawn. For example, W012-99 spent about 6 weeks at Canton Creek Falls but reemerged in November to the NU to spawn in early March. Similarly, W013-98 first entered Steamboat Creek in mid-October, spent about 2 weeks near the base of Steamboat Little Falls, dropped back to the NU for a week, returned to the falls and then again dropped back to the NU about 3 weeks latter where it remained until the signal was last seen on February 5th.

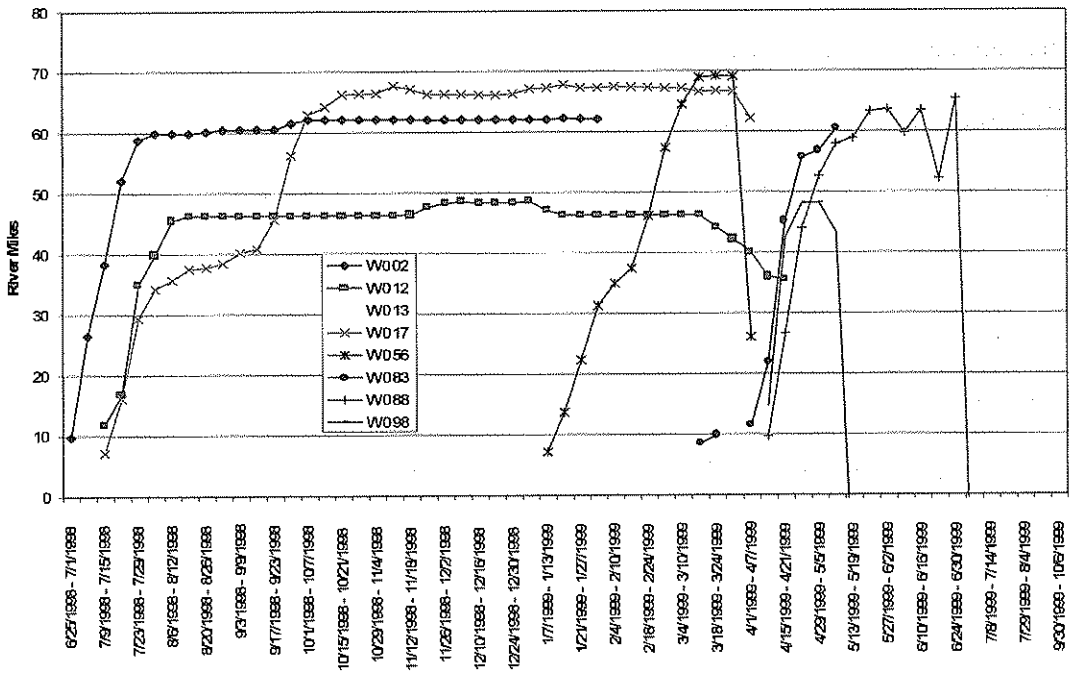
Notice, from Table 3, that summer fish seem to have a higher tendency to spawn in tributaries than do the winter group.

Discussion

A few fish proceeded upstream from Winchester Dam for only a short distance and then deadlined or disappeared, probably downstream. Also, as can be seen in Table 4 (for example), a few SC fish delayed migration just above the dam for several days or even weeks. This behavior was not peculiar to SC fish but, rather, was true for all classes and could be related to handling stress. It has been demonstrated that radio-tagged Chinook in the Kenai River delayed their upstream migration by an average of 4-5 days compared to those that were not handled, with some fish delaying migration by more than 30 days (Bernard et al. 1999). The behavior of the two groups, fish that were apparently delayed and those that weren't, appears to be similar after the initial delay period for this study.

Migration rates are of interest. Figure 13 illustrates a few fish timelines selected as typical. Note that, during the active migration up the river shortly after passing over the dam, fish tend to move rapidly and at a rate relatively independent of the time of year. That is, the slope for the early section of the curves is approximately the same for early summer and for late spring fish as well as for the one (W056) mid-winter fish selected for the figure.

Figure 13. Plot of selected typical time lines from Study Year 1998.



Data for migration rates as a function of flow changes are summarized in Table 5A below where the values listed in column DF are the changes in flow (in cfs) compared to the previous day and the data in rows are summarized in increments of 500 cfs. Column N is the number of days the change in flow listed in DF was observed during the study, column A lists the number of fish (non kelts) observed, B is the number of fish that moved more than 0.2 miles per day since the previous observation and VA is the average distance those fish referred to in column B moved per day. VM and VF are the corresponding distances for males and females, respectively. The average distance that fish move in a day is remarkably insensitive to the magnitude of the flow change. Also, the distance traveled does not depend strongly on the direction of flow change; fish appear to have moved about the same average distance on days that the river had risen as those when flow had diminished. In addition, the data do not suggest that steelhead show a strong preference for movement on rising compared to falling flow. Over the course of the project about the same number of fish moved under rising as under falling conditions when the data are normalized to the number of days that these conditions existed.

The previous study (Wroble, 1990) indicates a possible differences in migration rates for males compared to females. That suggestion is not supported by this work.

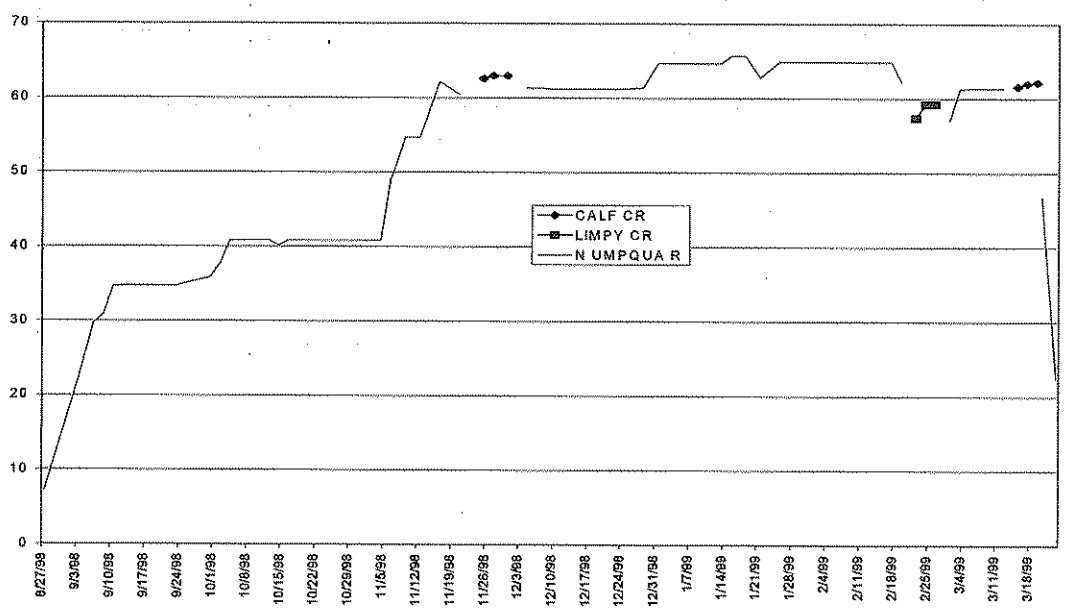
Table 5A. Summary of fish movement data. See text for explanation of column headings.

DF	N	A	B	VA	MA	VF
-2500	6	92	10	1.3	1.3	1.4
-2000	15	206	40	1.2	1.1	1.3
-1500	29	495	102	1.2	1.4	1.1
-1000	70	890	167	1.7	1.8	1.7
-500	609	5905	1237	1.8	1.8	1.8
0	345	3674	790	1.9	1.9	1.9
500	41	469	128	2.1	1.7	2.4
1000	18	116	12	1.4	1.6	1.1
1500	12	128	40	2.1	1.8	2.5
2000	7	105	21	1.2	2.0	0.8

For the bulk of the observations (6934) in the mainstream North Umpqua, fish had moved less than ½ mile per day upstream. Movements of .5 – 5 miles per day are less common; 1645 observations in this range were made. Only 165 observations were made on fish moving at a rate greater than 5 miles per day. A fish that moved upstream 15.25 miles in a day (4/14/99) established the record. A second fish moved 14.75 miles the same day. Both were observed near the dam on the previous day.

The migration route was not always a steady upstream course directly to the spawning area. Although Table 3 lists the first and last dates that a particular fish was observed in each tributary, the story is slightly more complex. Several fish entered tributaries only to drop back to the NU and reenter that tributary or, in some cases, another tributary before spawning and migrating out as a kelt. This behavior, while not typical, was not uncommon. An example is shown in Figure 14.

Figure 14. Timeline for W029-98.



Although downstream movement of kelts was not monitored intensively due to limited resources, some interesting observations were made. Following spawning, kelt out-migration tended to be very rapid (Figure 13). Several fish were observed to travel more than 10 miles per day downstream, with one fish dropping over 30 miles in a day. Because of the speed with which kelts traveled, many fish were observed only once or not at all during downstream migration in the North Umpqua River. A substantial number of fish that were not detected while leaving the North Umpqua were subsequently located in the mainstem Umpqua but since monitoring was sparse it is not possible to estimate general migration rates.

The quality of data related to catch rates is uncertain since it depends on voluntary reporting by fishermen and, in the absence of actual reports, on assumptions made from the characteristics of the timelines. Nevertheless, a few comments on the rate at which fish were caught are probably warranted. A summary of the data is shown in Table 6.

Table 6. Fish caught during the program. The number of tags returned is shown in parenthesis.

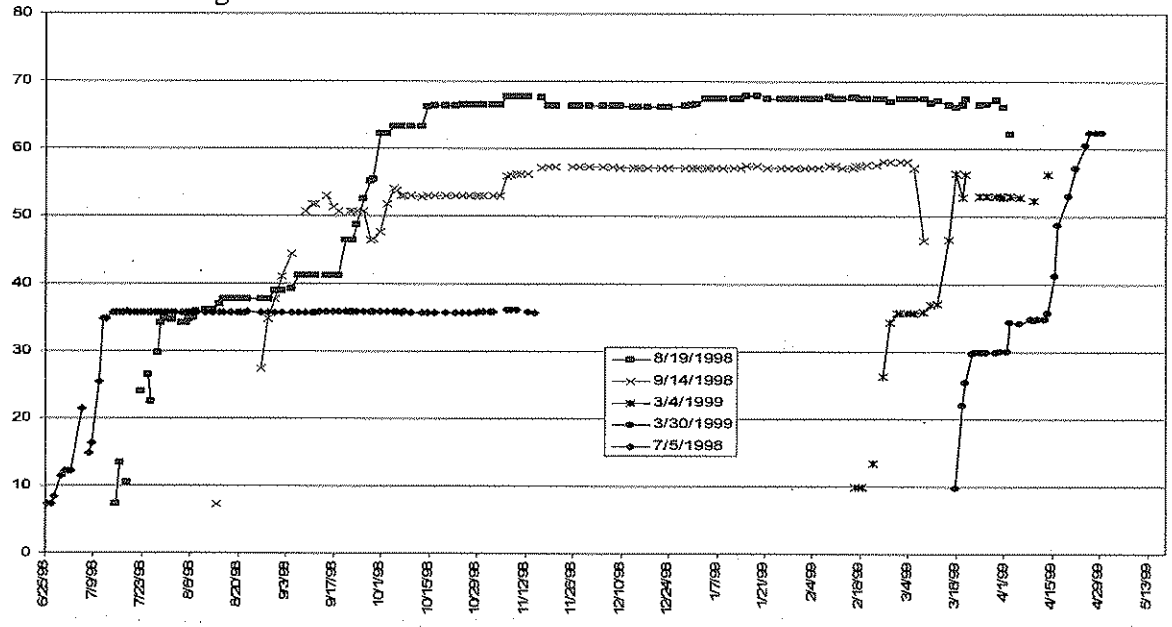
		1998		1999		2000	
		reported	assumed	reported	assumed	reported	assumed
Harvested: Summer:	Unclipped	10	1		3		4
	Hatchery			35	4	16	13
Winter:	Unclipped		1	0	6		
	Hatchery			2	4		
Released: Summer:	Unclipped	6(2)		8(3)	2	4(2)	
	Hatchery			6(3)	3	3(2)	
Winter:	Unclipped	2			1		
	Hatchery				1		
Harvested: Kelts		2		2			
Released:		1					

Data summarized in Table 6 shows that 39 of 63 (Table 1) radio-tagged, hatchery, summer fish were harvested for SY 1999. For SY 2000, twenty nine of 44 were harvested.

During 1998, recreational harvest of unclipped steelhead was legal year round; in 1999 and 2000 harvest of unclipped fish was only allowed from January 1 to April 31. Eleven of 51 unclipped summer fish were harvested during SY 1998, compared with only one of 57 winter fish. The difference in harvest rates for the unclipped and clipped summer fish is probably attributable to the fact that clipped summer fish tend to spend a greater fraction of their time below the fly fishing only area where fishing pressure tends to be more intense. Unclipped winter fish are probably less vulnerable to the fishery than are unclipped summer fish due for similar reasons. That is, winter fish spend less time in the river in general and, additionally, winter fishing conditions are more challenging.

Of the 17 fish reported to have been released with the transmitter in place, the timeline for eight show a sudden but temporary change in behavior presumably related to the catch and release process. No effect can be discerned for the remaining nine. Illustrative examples are shown in Figure 15. The fish caught on 7/5 and 9/14 show behavior that could be interpreted as a response to stress. Both dropped back downstream about 7 miles before resuming their journey. No similar response can be seen in the remaining 3 curves.

Figure 15. Timelines for 5 fish that were reported as caught and released with the transmitter in place in SY 1998. Data for one fish have been deleted for clarity. Dates shown in the legend are the dates the fish were caught.



The behavior of hatchery fish and its' significance are topics of intense debate among biologists as well as within the general public. Of special interest is the degree to which hatchery and wild fish cohabit spawning beds.

For hatchery fish tagged in SY 1999, seven spent some time in the NU above the mouth of Rock Creek. The evidence does not indicate that any of them spawned there. Three of the seven returned to spawn in Rock Creek. Three were caught and harvested. One was caught and the transmitter was removed so its eventual fate is unknown.

For SY 2000, eight hatchery fish spent time in the Fly Area. Of these, five returned to be caught and harvested at the mouth of Rock Creek and one was caught and harvested in the Fly area. The remaining two fish appear to have spawned in the Fly area, one near Smith Springs and the other near Steamboat Inn. These two were the only hatchery fish believed to have spawned above Deadline Falls during this study. One hatchery fish that had been released as a smolt in the South Umpqua River returned to spawn in Little River as discussed previously.

Even in Rock Creek, where the tendency for clipped and unclipped fish to overlap on the spawning beds might be expected to be highest, there is considerable segregation as shown previously in Figure 11.

Given the limited resources available for this project, the study has greatly enhanced our understanding of life history characterizes of North Umpqua steelhead. The authors have avoided detailed inferences based on statistical arguments due to the rather small sample sizes. Hopefully, future efforts will make more quantitative conclusions possible.

Data collected for this study are available on CD-ROM as a Microsoft Access 97 file. Sufficient information can be provided so that the position for each fish can typically be determined to an accuracy of a few hundred feet. A program to plot fish positions on a schematic diagram of the North Umpqua basin is also available. The data entry, storage and display schemes and other computer programs developed for this study are easily generalized to any watershed and are available free of charge to interested parties

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Table 2. Successful spawners by area, month and fin clip

2A Lower N Umpqua

	SY98	SY99		SY00		Totals	
	uc	uc	c	uc	c	uc	c
Jun		3				3	0
Jul			1			0	1
Aug						0	0
Sep						0	0
Oct	1			2	1	3	1
Nov	1					1	0
Dec	2	1	1			3	1
Jan		3	1			3	1
Feb		4	1	1		5	1
Mar	3	6		2		11	0
Apr	1	5				6	0
May		2	1			2	1

2B Fly Water

	SY98	SY99		SY00		Totals	
	uc	uc	c	uc	c	uc	c
Jun	1	3		1	2	5	2
Jul	3	2				5	0
Aug	3					3	0
Sep	2	1				3	0
Oct	1	1				2	0
Nov	1	1				2	0
Dec		1				1	0
Jan	4					4	0
Feb	5	1		2		8	0
Mar	8	5		3		16	0
Apr	7	1				8	0
May						0	0

2E Steamboat Creek

	SY98	SY99	SY00	Total
Jun	5	5	6	16
Jul	3	9	5	17
Aug	1	5	3	9
Sep		2	1	3
Oct	1		1	2
Nov	1			1

2C Little River

	SY98	SY99		SY00		Totals	
	uc	uc	c	uc	c	uc	c
Jun						0	0
Jul						0	0
Aug	1	1				2	0
Sep				2		2	0
Oct						0	0
Nov	1					1	0
Dec	3			1		4	0
Jan	4	1				5	0
Feb			1			0	1
Mar	1	1				2	0
Apr						0	0
May						0	0

2D Rock Creek

	SY98	SY99		SY00		Totals	
	uc	uc	c	uc	c	uc	c
Jun			2	1	1	1	3
Jul		3	5	1	2	4	7
Aug		2	2		1	2	3
Sep	1		1	1		2	1
Oct			1	1	1	1	2
Nov						0	0
Dec						0	0
Jan			1			0	1
Feb			1	1		1	1
Mar	3	2				5	0
Apr	2					2	0
May						0	0

2F ENTIRE BASIN

	3 yr sum	
	uc	c
Jun	25	5
Jul	26	8
Aug	16	3
Sep	10	1
Oct	8	3
Nov	5	0
Dec	8	1
Jan	12	2
Feb	14	3
Mar	34	0
Apr	16	0
May	2	1

Table 3a. Fish that exhibited spawning behavior in the N. Umpqua below Rock Creek (Deadline Falls)

1998	W038*	W042*	W049*	W050	W069	W072	W074	W090
N UMPQUA R	10/16/98	11/16/98	12/16/98	12/16/98	03/05/99	03/05/99	03/05/99	04/08/99
	12/21/98	02/05/99	02/12/99	03/20/99	03/19/99	03/23/99	03/29/99	05/07/99
	22.0	22.0	26.1	33.2	25.1	26.3	24.0	31.9
ROCK CR		11/23/98						
		11/27/98						
		36.1						

1999	H024	H063	H068*	H071*	H076	W001*	W002*	W015	W051	W056*	W057	W058	W061*	W062
COOPER CR									02/04/00					
									3/16/00					
									25.6					
N UMPQUA R	07/14/99	12/17/99	01/27/00	02/17/00	05/23/00	06/01/99	06/01/99	06/30/99	12/17/99	01/27/00	01/27/00	01/27/00	02/17/00	02/17/00
	01/07/00	06/27/00	02/11/00	02/27/00	06/08/00	06/14/99	06/10/99	06/27/00	02/01/00	04/06/00	06/27/00	06/27/00	04/06/00	06/27/00
	25.1	15.0	17.3	13.3	25.1	17.3	25.0	15.0	26.1	17.8	16.0	25.1	15.9	25.1

1999 continued	W063*	W064	W072*	W073*	W077*	W080	W081	W083	W085*	W086	W087*	W088*	W089*	W090*	W091*
N UMPQUA R	02/17/00	02/17/00	03/02/00	03/02/00	03/02/00	03/24/00	03/24/00	03/24/00	04/11/00	04/11/00	04/11/00	04/11/00	04/11/00	05/11/00	05/23/00
	03/22/00	06/21/00	04/24/00	04/30/00	04/10/00	04/02/00	06/15/00	04/20/00	04/20/00	04/20/00	04/15/00	04/24/00	04/18/00	05/16/00	05/28/00
	21.8	10.4	21.9	34.7	35.3	22.8	33.0	33.4	13.0	21.8	16.4	22.3	17.2	24.6	27.3

2000	H043*	W038	W041	W043*	W048	W049
N UMPQUA R	10/12/00	10/12/00	10/24/00	03/08/01	02/27/01	03/05/01
	03/07/01	04/04/01	04/27/01	03/20/01	04/10/01	03/14/01
	31.9	27.6	34.7	28.2	32.5	35.8

Table 3b. Fish that exhibited spawning behavior in the Fly water (N. Umpqua above Deadline Falls).

1998	W002*	W012*	W013	W017	W022*	W026*	W029*	W033*	W034	W039	W044	W056*	W058*	W059	W060*	W063	W064
CALF CR							11/25/98 03/19/99 63.0		03/26/99 03/29/99 62.7								
CANTON CR			11/23/98 11/25/98 53.5														
COPELAND CR				12/30/98 03/31/99 67.9													
DRY CR	01/18/99 01/21/99 62.4																
LIMPY CR					01/15/99 03/03/99 58.1	12/04/98 01/21/99 57.4	02/22/99 02/26/99 59.3	03/03/99 03/03/99 57.5									
N UMPQUA R	06/25/98 02/03/99 62.3	07/09/98 03/20/99 49.1	07/15/98 02/05/99 53.8	07/15/98 04/02/99 67.8	08/13/98 03/08/99 57.2	08/27/98 02/18/99 57.4	08/27/98 03/23/99 65.7	09/25/98 03/15/99 57.4	09/25/98 03/31/99 61.4	10/16/98 04/10/99 50.8	11/16/98 05/03/99 49.5	01/13/99 03/26/99 69.3	01/29/99 04/29/99 69.3	01/29/99 02/26/99 42.1	01/29/99 04/05/99 57.1	02/16/99 04/05/99 64.9	02/16/99 03/31/99 63.9
ROCK CR		04/13/99 04/13/99 35.9															
STEAMBOAT CR	07/18/98 07/19/98 52.8		10/16/98 11/30/98 54.1														
SUSAN CR														03/04/99 04/18/99 42.4			
WRIGHT CR											02/26/99 04/05/99 49.3						

1998 continued	W065	W066*	W067	W070	W077	W080*	W081	W083	W084	W085*	W086*	W088*	W091*	W094	W095	W096*	W097*	W098*
FALL CR											04/24/99 04/24/99 46.6							
N UMPQUA R	02/16/99 03/26/99 53.8	02/16/99 04/05/99 67.5	02/16/99 04/13/99 56.4	03/05/99 05/22/99 66.3	03/05/99 04/21/99 53.8	03/17/99 05/17/99 66.5	03/17/99 05/22/99 56.9	03/17/99 05/10/99 60.5	03/17/99 04/29/99 62.4	03/17/99 04/25/99 64.3	03/17/99 05/10/99 64.7	04/08/99 06/25/99 65.6	04/08/99 04/25/99 50.8	04/13/99 04/27/99 40.0	04/13/99 04/29/99 52.2	04/13/99 05/10/99 61.4	04/13/99 04/25/99 39.1	04/13/99 05/10/99 48.4

1999	W008	W012*	W016*	W027*	W028	W045	W047	W050*	W053	W065*	W068*	W069*	W071	W074	W079*	W084
CALF CR					11/28/99 1/29/00 63.1											
CANTON CR		11/26/99 02/18/00 55.0														
COPELAND CR											04/19/00 4/25/00 68.7	04/10/00 4/26/00 67.9				
N UMPQUA R	06/17/99 02/11/00 53.0	06/22/99 04/05/00 57.2	06/30/99 04/06/00 48.7	07/25/99 03/16/00 48.5	07/25/99 11/23/99 60.5	09/22/99 02/28/00 49.1	10/15/99 04/16/00 61.2	11/02/99 03/12/00 39.0	12/17/99 03/08/00 50.8	02/17/00 03/24/00 42.7	03/02/00 04/16/00 66.3	03/02/00 04/29/00 65.0	03/02/00 04/22/00 63.8	03/02/00 05/16/00 60.5	03/24/00 05/13/00 52.6	04/11/00 05/13/00 54.8
ROCK CR						10/29/99 10/30/99 35.9										
STEAMBOAT CR		07/25/99 07/25/99 53.4					02/11/00 02/11/00 53.6									
SUSAN CR			02/04/00 2/18/00 42.9													
WRIGHT CR				03/02/00 3/8/00 49.2												

2000	H008	H011*	W002	W044	W045	W050*	W051	W052
N UMPQUA R	06/20/00 04/11/01 40.1	06/20/00 02/27/01 51.8	06/06/00 05/08/01 51.7	02/06/01 04/29/01 69.3	02/05/01 04/20/01 40.0	03/20/01 04/29/01 53.8	03/19/01 04/29/01 68.9	03/30/01 05/08/01 42.7

Table 3c. Fish that exhibited spawning behavior in Rock Creek or Little River

Little River

1998	W025*	W043*	W046*	W048	W051*	W052	W053*	W061*	W062*	W073*
CAVITT CR						02/15/99 05/27/99 45.0			03/03/99 05/03/99 47.2	
JIM CR								02/26/99 03/25/99 37.3		
LITTLE R	11/01/98 03/16/99 46.7	12/14/98 03/12/99 46.0	01/20/99 02/03/99 33.3	01/04/99 04/08/99 46.0	01/18/99 02/26/99 45.0	01/20/99 02/12/99 36.8	01/29/99 03/22/99 45.4	02/08/99 02/24/99 36.8		03/19/99 03/25/99 37.6
N UMPQUA R	08/27/98 10/09/98 29.8	11/16/98 04/01/99 29.6	12/16/98 02/25/99 25.4	12/16/98 01/02/99 28.3	12/16/98 02/28/99 28.1	01/13/99 01/17/99 26.1	01/13/99 01/24/99 25.4	01/29/99 04/05/99 23.9	01/29/99 05/14/99 29.6	03/05/99 04/09/99 13.4

1999	H072*	W041*	W059*	W070*
CAVITT CR	02/29/00 03/08/00 38.8			
LITTLE R	03/15/00 04/02/00 47.0	10/29/99 02/06/00 47.6	03/06/00 04/05/00 47.3	03/17/00 03/17/00 31.8
N UMPQUA R	02/17/00 04/10/00 29.5	08/16/99 02/12/00 29.6	01/27/00 04/10/00 25.3	03/02/00 04/06/00 28.2

2000	W030	W036	W046
	03/19/01 04/27/01 45.6	02/05/01 03/07/01 37.8	
	12/19/00 03/14/01 36.8	12/26/00 03/14/01 37.7	2/27/01 03/14/01 40.7
	09/01/00 12/11/00 25.4	09/19/00 12/18/00 29.6	12/27/00 02/21/01 29.6

Rock Creek

1998	W035	W071	W076	W087	W092	W099*
N UMPQUA R	09/25/98 11/04/98 35.8	03/05/99 04/12/99 35.8	03/05/99 04/10/99 35.8	03/17/99 04/19/99 35.8	04/08/99 04/08/99 0.0	04/19/99 05/13/99 35.7
ROCK CR	11/06/98 05/25/99 44.9	04/13/99 04/29/99 37.7	03/20/99 05/17/99 46.3	04/19/99 04/19/99 35.9	04/16/99 06/03/99 36.2	04/29/99 05/07/99 36.1

1999	H006	H013*	H019*	H021*	H023*	H030*	H038	H040*	H047	H049*
KELLY CR			01/18/00 01/19/00 37.7						02/14/00 02/27/00 38.1	
MCCOMAS CR						02/06/00 02/06/00 37.6			03/02/00 03/02/00 37.3	
N UMPQUA R	06/22/99 10/26/99 44.9	06/30/99 11/28/99 32.3	07/12/99 02/16/00 46.3	07/12/99 11/23/99 35.6	07/14/99 11/24/99 35.8	07/25/99 02/08/00 40.8	07/25/99 12/26/99 35.8	08/03/99 10/28/99 35.8	08/16/99 11/24/99 35.8	09/22/99 03/09/00 35.8
ROCK CR	10/28/99 06/07/00 36.8	11/28/99 12/01/99 36.2	11/23/99 02/06/00 38.4	11/26/99 03/02/00 37.7	09/19/99 12/05/99 37.1	11/14/99 02/08/00 44.5	09/08/99 06/07/00 36.1	10/29/99 02/06/00 45.9	11/28/99 03/07/00 37.7	11/28/99 03/07/00 40.9

1999 continued	H056	H064	H073	W021*	W023	W031*	W033*	W037*	W076	W082*
KELLY CR	02/08/00 02/21/00 38.1									
N UMPQUA R	10/15/99 11/24/99 34.8	01/27/00 02/08/00 35.8	02/17/00 02/29/00 35.8	07/12/99 03/05/00 35.8	07/12/99 10/28/99 35.8	07/25/99 01/24/00 35.8	08/03/99 04/13/00 35.6	08/03/99 03/06/00 18.5	03/02/00 03/14/00 34.8	03/24/00 04/27/00 34.7
ROCK CR	11/28/99 06/07/00 38.1	02/11/00 03/14/00 36.6	03/02/00 03/26/00 37.3	11/14/99 03/02/00 48.5	10/29/99 01/26/00 42.6	10/30/99 01/18/00 40.9	11/06/99 04/06/00 44.4	12/09/99 03/02/00 44.9	03/17/00 04/06/00 36.0	04/18/00 04/22/00 36.1
ROCK CR, E FK								02/24/00 02/29/00 45.5		
ROCK CR, NE FK				02/18/00 02/21/00 48.6						

2000	H004*	H028	H029	H038*	H044*	W004*	W019*	W037	W040	W047*
HARRINGTON CR							03/07/01 03/26/01 44.2			
N UMPQUA R	06/06/00 03/30/01 35.8	07/25/00 05/08/01 30.3	07/25/00 10/19/00 35.8	08/28/00 10/19/00 35.5	10/24/00 01/23/01 35.8	06/06/00 12/11/01 54.5	07/25/00 10/19/01 35.8	09/19/00 12/22/00 34.4	10/24/00 03/19/01 34.8	02/06/01 03/14/01 34.9
ROCK CR	06/22/00 03/20/01 38.0	11/13/00 11/16/00 37.9	10/23/00 05/08/01 36.2	10/23/00 02/21/01 36.8	12/18/00 01/15/01 36.2	12/18/00 02/27/01 36.8	10/23/00 02/27/01 42.8	12/27/00 03/14/01 37.3	03/26/01 04/04/01 41.9	03/20/01 04/04/01 47.4

Table 3d. Fish that exhibited spawning behavior in Steamboat Creek.

1998	W004*	W005*	W006	W007*	W008	W011	W014*	W015*	W028*	W037	W045*
BIG BEND CR							03/24/99 03/30/99 64.6				
CANTON CR	10/12/98 01/15/99 58.3		09/18/98 05/27/99 62.8					09/20/98 04/02/99 63.2	11/18/98 03/05/99 62.5		02/22/99 05/17/99 54.9
CEDAR CR						02/17/99 04/15/99 68.3					
CEDAR CR, N FK						03/01/99 03/12/99 68.8					
HONEY CR									10/22/98 10/22/98 40.3		
N UMPQUA R	06/25/98 10/09/98 52.8	06/25/98 07/16/98 51.5	06/25/98 09/14/98 47.6	06/25/98 05/23/99 50.7	06/25/98 09/25/98 52.9	07/09/98 09/11/98 52.9	07/15/98 04/21/99 52.9	07/15/98 09/18/98 52.8	08/27/98 11/16/98 52.8	10/16/98 03/10/99 57.6	11/16/98 05/22/99 50.8
PASS CR								11/20/98 12/07/98 65.0	02/24/99 03/03/99 84.1		
STEAMBOAT CR		07/17/98 03/31/99 67.7		07/14/98 05/17/99 62.8	09/27/98 05/17/99 58.0	09/14/98 02/12/99 66.8	09/23/98 04/08/99 64.3			03/03/99 05/17/99 57.1	02/19/99 02/19/99 53.4

1999	W003	W004	W011	W013*	W014	W017	W018*	W019*	W020*	W022	W024*	W025	W029*	W030	W032	W036	W038*	W040*	W042	W043	W046*
CANTON CR						11/12/99 02/21/00 61.3				10/28/99 06/05/00 58.3					11/04/99 06/05/00 58.3	10/08/99 06/05/00 55.0		10/08/99 03/08/00 62.9	10/28/99 06/05/00 61.7		03/16/00 04/16/00 60.5
CEDAR CR		02/04/00 02/04/00 68.0					04/07/00 04/10/00 66.7							02/28/00 05/02/00 68.2							
CEDAR CR, N FK								02/16/00 02/16/00 68.2													
CEDAR CR, S FK		02/21/00 05/02/00 72.0																			
HORSE HEAVEN CR																				03/30/00 4/16/00 72.4	
LITTLE ROCK CR	11/28/99 05/02/00 72.6		02/01/00 05/02/00 71.0	04/16/00 04/22/00 73.3	02/28/00 03/16/00 72.2							02/16/00 05/02/00 72.5									
N UMPQUA R	06/17/99 10/06/99 52.8	06/17/99 10/04/99 51.1	06/22/99 07/23/99 52.5	06/30/99 04/30/00 52.8	06/30/99 08/29/99 52.8	07/12/99 11/10/99 52.8	07/12/99 04/18/00 52.6	07/12/99 02/24/00 52.6	07/12/99 03/24/00 52.6	07/12/99 10/26/99 52.6	07/12/99 04/15/00 52.8	07/25/99 10/04/99 52.8	07/25/99 02/07/00 53.2	07/25/99 08/29/99 52.6	08/03/99 10/25/99 52.6	08/03/99 10/26/99 52.6	08/03/99 04/20/00 52.6	08/16/99 03/16/00 52.6	08/16/99 10/26/99 52.6	09/22/99 10/20/99 34.8	09/22/99 04/24/00 52.9
STEAMBOAT CR	10/12/99 11/23/99 69.9	10/06/99 02/11/00 67.6	07/19/99 02/04/00 71.1	10/28/99 04/25/00 69.1	08/31/99 04/05/00 71.6		08/25/99 04/13/00 67.9	10/08/99 02/23/00 66.3	10/28/99 03/20/00 57.1		10/28/99 04/10/00 67.6	10/06/99 02/11/00 69.9	10/12/99 02/01/00 70.4	08/31/99 04/10/00 66.6	10/28/99 10/28/99 54.6		09/04/99 04/13/00 73.2	10/28/99 10/28/99 53.8		10/30/99 05/02/00 72.4	

2000	W003	W005*	W006	W007*	W009	W014	W015	W016	W017	W020	W021*	W026	W027	W028	W034*	W042
CANTON CR		10/24/00 03/14/01 61.5							10/24/00 03/27/01 64.9		03/20/01 03/27/01 62.0	10/24/00 03/27/01 65.4	10/24/00 04/11/01 62.2	09/29/00 03/27/01 60.4		
CEDAR CR					04/06/01 04/20/01 66.8											
HORSE HEAVEN CR							3/7/01 5/24/01 74.1									
N UMPQUA R	06/06/00 07/18/00 51.8	06/20/00 04/01/01 52.6	06/20/00 07/07/00 35.8	06/20/00 04/04/01 52.6	06/29/00 08/17/00 52.6	06/29/00 10/19/00 51.8	07/06/00 08/30/00 56.0	07/06/00 10/19/00 52.6	07/06/00 10/19/00 51.8	07/25/00 10/19/00 52.9	07/25/00 04/04/01 52.9	08/11/00 10/13/00 50.5	08/28/00 10/19/00 35.8	08/28/00 09/20/00 51.7	09/19/00 05/24/01 42.7	10/26/00 03/14/01 51.6
STEAMBOAT CR	07/28/00 04/20/01 63.8		07/18/00 04/20/01 59.0	03/20/01 03/27/01 54.1	08/21/00 03/27/01 68.9	10/24/00 04/20/01 57.0	09/01/00 03/27/01 73.9	10/24/00 04/20/01 57.1		10/24/00 05/24/01 57.1		10/19/00 10/19/00 53.2			12/19/00 04/20/01 69.9	03/20/01 04/20/01 57.1

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